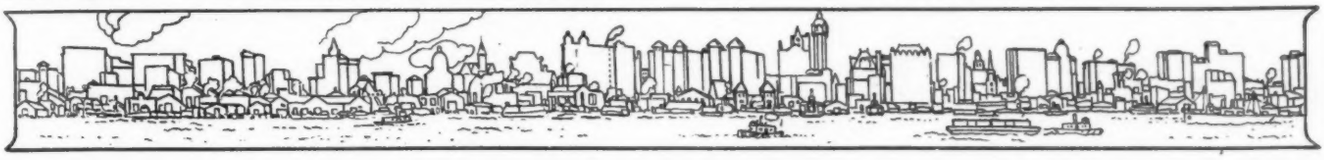
Power. and THE ENGINEER

EVERYTHING ABOUT THE GENERATION AND TRANSMISSION OF POWER



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IF a man were reared in silent solitude—never permitted to hear a human voice other than his own—how much would he know?

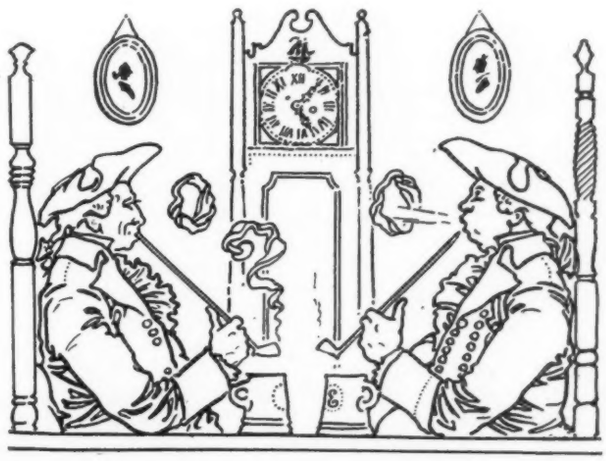
How well qualified to run a steam plant would he be?

As an engineer he would be of no more use than a rabbit.

For men to compel a fellow man to grow up mentally undeveloped would be a crime. For a man himself to neglect his opportunities is a self-inflicted injustice of equal magnitude.

We obtain an enormous percentage of our knowledge by means of association. Association with men is unavoidable.

As long as we must associate with other men why not make the association as profitable as possible to everybody. You know something which may be of value to your neighbor; he knows something which may be worth *your* while to learn. Why not get together and swap ideas? You do not have to accept or use anything which judgment tells you is worthless. Your own ideas will not be any less valuable to you because you have given your neighbor the benefit of knowing them.



Engineers, as a class, are appreciating more and more the true value of neighborliness.

Testimony on the truth of this is found in the great number of clubs and associations which are formed by and for engineers.

Several men, ten, twenty, two thousand,—any number,—decide that it will be helpful and profitable, pleasant, too, if they can get together once in a while. One man is a "shark" on a certain phase of engineering work, or has had a wealth of experience. He tells what he knows. The others soak up that part of his remarks which they judge to be of especial value to them. Each in his turn "antes up" what information he can. Thus, the "pot" is being "sweetened" continually. In such a game everybody wins; nobody loses.

Remember, neighborliness must not be left locked in the lodge room,—it must be taken along down to the plant. It is just as valuable there, for mingling with men is a great broadener. It teaches things impossible to be obtained in any school.

There are great possibilities in this business of being neighborly. We could fill all of the succeeding pages of this issue with arguments to prove this, and then hardly scratch the surface. As it is, we can but give you the idea.

Go to it!

Feeding Water to Steam Boilers

Mud Drum Feed, Top Internal Type of Feed, the Ford System, Vertical Boiler Feeding, Feeds for Locomotive and Water-tube Boilers, and Feed Arrangements to Avoid

BY J. E. TERMAN

One of the features of the equipment of steam boilers about which wide differences of opinion exist, and equally divergent methods of installation are adopted, is the manner of introducing the feed water. Many engineers become so enthusiastic about a favorite method of introducing the feed that they will claim that it can cause a direct increase in the boiler efficiency over other methods of feeding. However, such claims are only claims, as no manner of introducing the feed water to a boiler can directly affect its efficiency to any appreciable extent. It is, of course, very true that it may indirectly influence the economical operation, by reducing the cost of repairs, or preventing the accumulation of heavy scale on the most efficient heating surface. In some cases it is stated that certain methods of introducing the feed seriously interfere with the circulation in the boiler, but the writer does not believe this to be true.

The following description of the usual boiler feeds met with in practice in the United States and the effects produced by them, are the writer's observations, made during a number of years' service as an inspector of boilers in different sections of the country.

There is one necessary precaution to be observed in any method that may be adopted of introducing feed water to a boiler, and this is that the outlet must be water sealed in order to prevent water hammer in the pipes, which will shake the connections loose and cause leaking, if not more serious results. The sealing of the end of the pipe may be accomplished by having the discharge end below the water line, or if the feed is to be discharged in the steam space, the end of the pipe should be turned up so as to trap the water in the pipe and keep it full at all times.

Feed Arrangements to Avoid

Figs. 1 and 2 represent two methods of introducing the feed water to a boiler that would cause trouble from severe water hammer in the pipe, if the check valve were located at a considerable distance from the outlet, and the piping arranged so that the water would drain from this valve toward the boiler. The methods of introducing the feed as illustrated in Figs. 3 and 4 would not produce trouble from water hammer in the pipes if the joints inside the boiler were made tight. The methods of introducing the feed-water in water-tube boilers is practically uniform for each type, which is due to the fact that each type is generally manufactured by a single concern. This uniformity, however, does not exist with the horizontal tubular or flue boiler, the locomotive type or the vertical tubular boiler, since these are made by a great number of different manufacturers, and as specifications are drawn for them by a still wider circle of consulting engineers, extreme variation in the methods of introducing the feed exist.

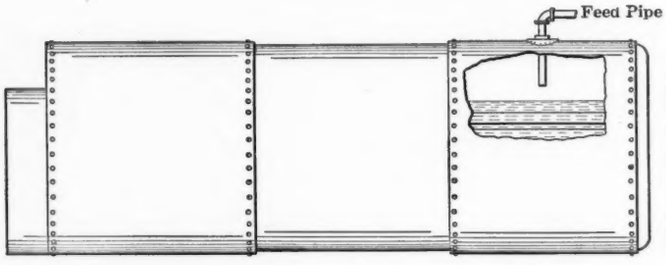


Fig. 1

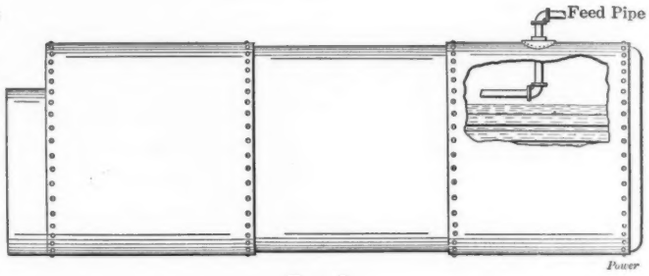


Fig. 2

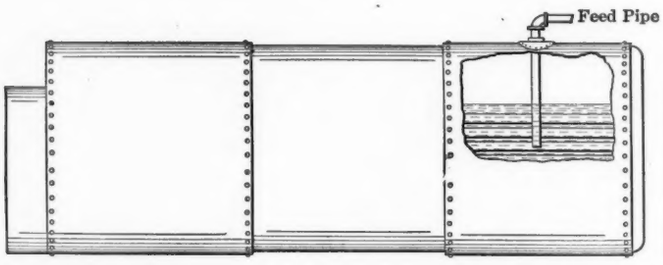


Fig. 3

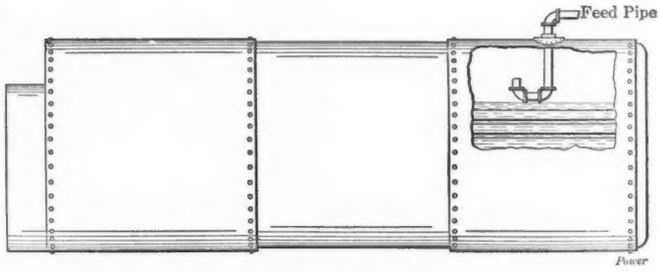


Fig. 4

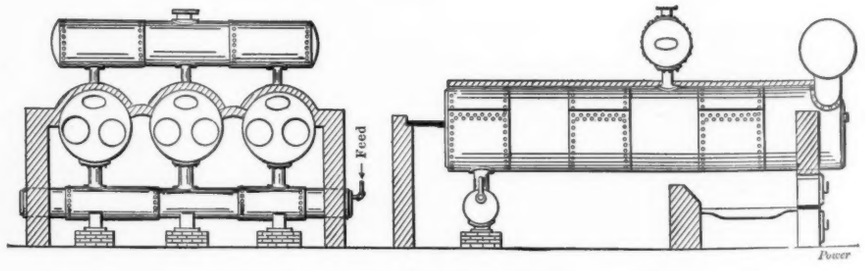


Fig. 5

Mud Drum Feed

Along the Mississippi river and its tributaries, where a boiler plant is of such size as to require the use of a number of boilers, it is customary to set the boilers in batteries of two or more over a single furnace, and operate each battery

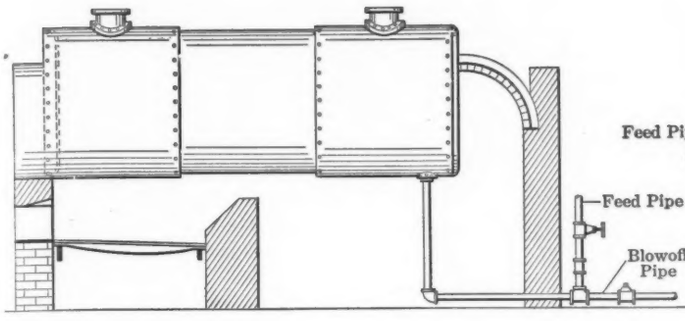


FIG. 6

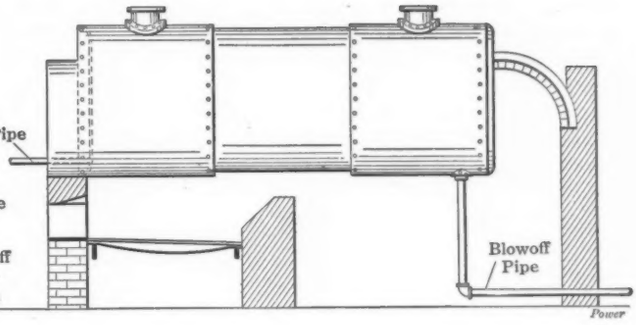


FIG. 7

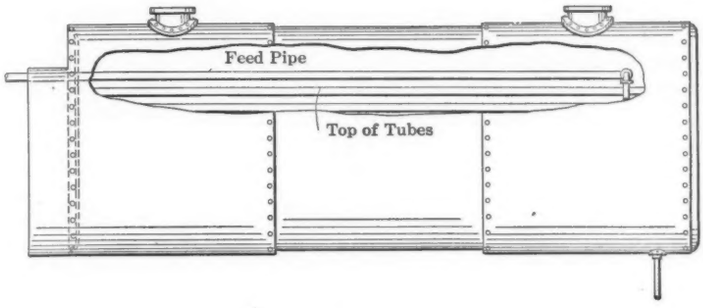


FIG. 8

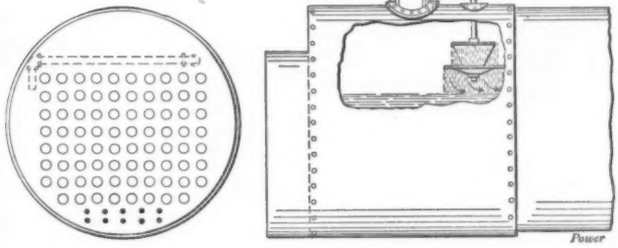


FIG. 9

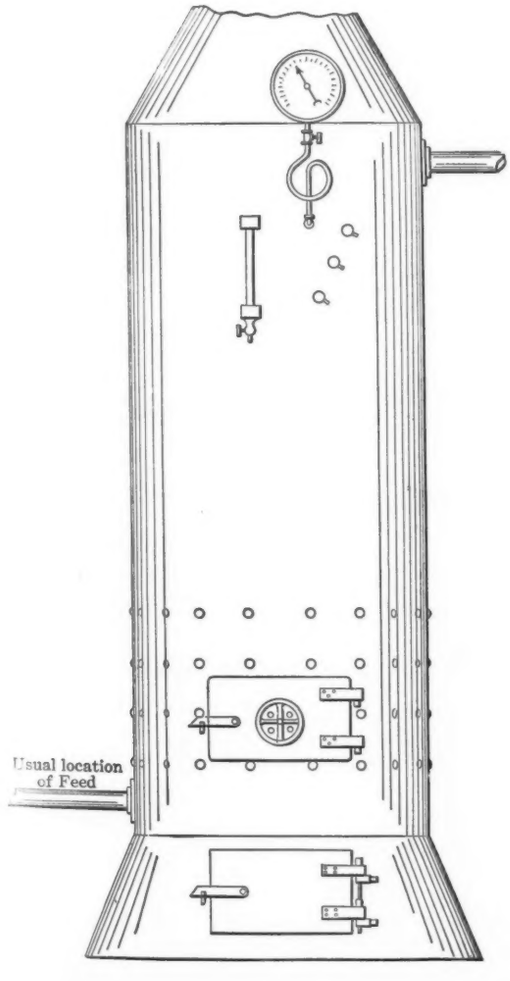


FIG. 10

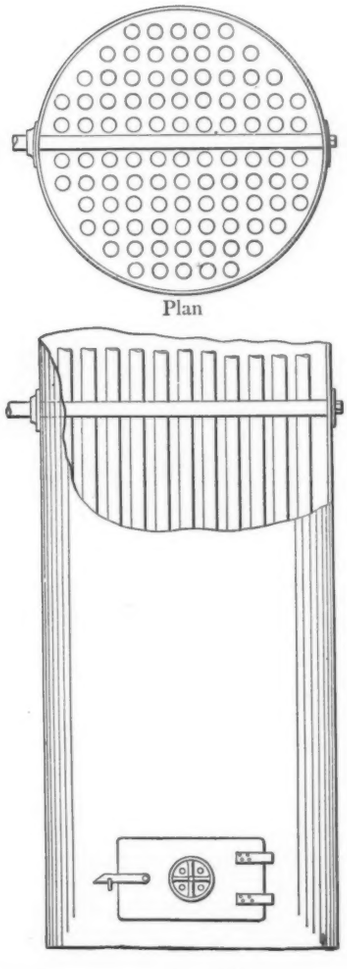


FIG. 11

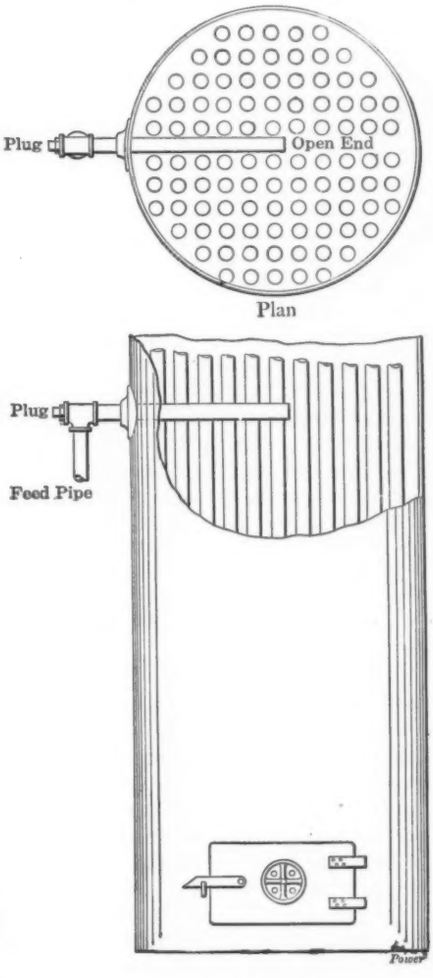


FIG. 12

as a single boiler, and in order to simplify the carrying of water at the proper level, the boilers are connected together on the bottom, near the rear end, and on top generally near the center, by mud and steam drums as illustrated in Fig. 5.

A very common way of feeding such installations is through the mud drum, the feed pipe being attached to the closed head of this drum. This method of feeding permits the ready deposit of suspended matter in the mud drum, as the water is comparatively quiet for a considerable period of time before it reaches the boiler proper. The objections to the mud-drum feed are, that it subjects the bottom seams of the boiler to severe strains due to the comparatively cold water flowing along with the general boiler circulation on the bottom of the shell toward the front, producing local contractions of the sheets and causing leaking at the girth seams, unless the boiler is exceptionally well constructed. The strains introduced by the cold feed water also frequently cause the sheets to crack at the lower portion of the girth seams. Another objection to this feed is that it tends toward rapid corrosion of the mud-drum sheets, due to low temperature with lack of circulation, the action of air and carbonic acid gas carried in with the feed water producing the corrosion. Mud drums are generally short lived, at best, as they are usually subjected to very severe external corrosion from the action of ash and moisture in the event of long intervals of idleness, as is the case in the sugar industry.

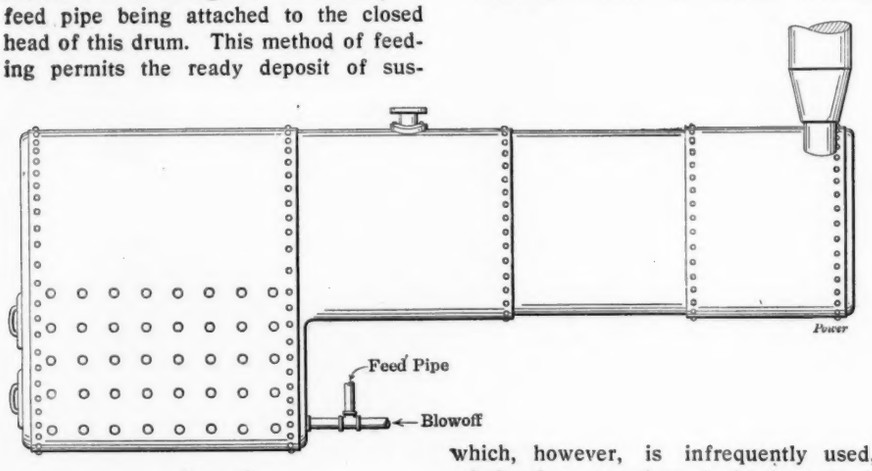


FIG. 13

BOTTOM FEED

A similar method of bottom feed for single-set horizontal flue or tubular boilers as given below, when not provided with a mud drum, is to admit the feed through the blowoff pipe, as illustrated by Fig. 6. Some engineers who advocate this method of feeding justify their use of it by claiming that it insures a clear blowoff pipe; and while this is true, when using the average feed water, it is not a sufficient excuse for adopting this form of feed. Other methods of keeping the blowoff clear are just as effective, and the bottom feed produces the same strains on the boiler shell as stated above for the mud-drum feed, and though this may fail to cause apparent injury in some instances on account of excellent workmanship, the strains tending to cause trouble are nevertheless there, and should not be tolerated.

Another method of bottom feeding which, however, is infrequently used, admits the water through the front head as shown in Fig. 7. This would appear to be as bad if not worse than feeding through the blowoff pipe, as regards the straining of the shell plates from sudden cooling, but the writer's experience indicates that such is not the case, and the probable explanation is, that the water in the boiler immediately over the fire is in such violent agitation, and with such an extremely strong upward current, that the feed water introduced is at once taken up and thoroughly mixed with the water already contained in the boiler, so that it does not come in actual contact with the shell plates until it has reached the general boiler temperature.

WIDELY USED METHOD

The method of feeding horizontal tubular boilers which is possibly more widely used than any other, is the top internal type of feed, illustrated in Fig. 8, which is commonly known as the "Hartford feed" or the "Snowden heater." It is modified in numerous ways, sometimes consisting of four or five pipes, connected together by return bends, and extending the entire length of the shell, the feed water being passed through these pipes before being discharged into the boiler. The object of this arrangement of feed is to heat the water in the pipe to the boiler temperature before it is actually admitted to the boiler.

The usual point of discharge is between the shell and tubes, about 2 feet from the rear head, as shown, but this is often varied, a frequent point of discharge being between the tubes at the center of the boiler. Some advocate this location, on account of the deposit (which with some feed waters tends to collect adjacent to the inlet) not becoming attached to the shell; such deposit is, however, usually of a very soft nature, and the writer does not believe that there is very much choice between the locations. The Massachusetts boiler rules require that the feed for horizontal tubular boilers be discharged about the tube level and near the center of the boiler crosswise and about three-fifths of the distance from the front head lengthwise of the shell.

The difficulties of installation and operation of the top internal type of feed, consist chiefly of stoppage of the pipe with deposit, where certain feed waters are used; such stoppage near the discharge end being very liable in feed waters containing considerable quantities of magnesia. Another difficulty is, to keep the connection where the feed enters the

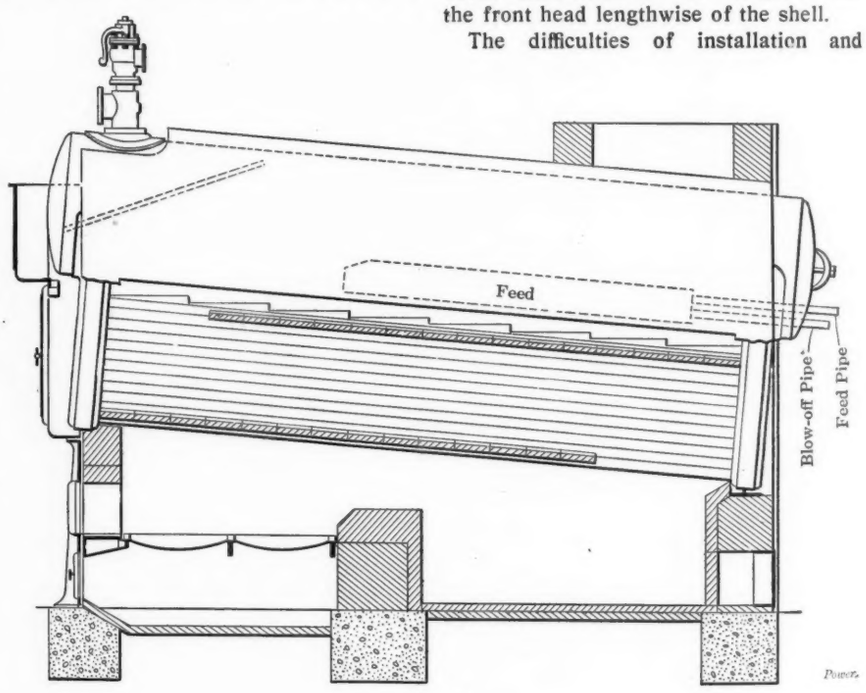


FIG. 14

boiler head tight, this trouble being chiefly due to vibration of the internal portion of the pipe when it is not properly supported and fastened, the pulsations of the feed pump producing the motion; leaking at these connections may also be caused by contraction and expansion due to feeding cold water. This is, however, equally true of the connections for other methods of feeding.

The Ford System

A feed which the writer believes is the best for all types of boilers where the form of construction will admit of its application, is illustrated in Fig. 9. This is a steam-space feed, and was originated by Benjamin Ford, chief inspector for the Hartford Steam Boiler Insurance Company. It was patented by Mr. Ford in 1879 and was introduced by him in a similar manner to the Corliss engine; that is, he would guarantee a plant which was experiencing cracks and leakage along the bottom of its boilers, immunity from such troubles for a period of time for a stipulated sum; and he would install this feed in place of the customary mud-drum feed to accomplish this purpose, and was invariably successful. This feed was introduced in the Pittsburg field, which at that time used chiefly the two-flue and return-tubular type of boilers, the former being generally about 30 feet in length; as a rule the courses of these boilers were not exceptionally well fitted, and tightness depended largely on the calking. The consequence was that the combined strains due to the bottom feed and distance between supports—the mud-drum neck and the boiler front, located 28 to 30 feet apart, being used to carry the weight of the boiler—caused almost constant trouble with the bottom girth seams. This type of steam-space feed has a number of advantages that would not appear at a glance. In the first place, the incoming water being divided in a thin sheet, is heated by the steam to boiler temperature almost instantly, and on account of this sudden change of temperature a large portion of the scale-forming matter which is precipitated at the boiler temperature comes down in granular form and does not adhere to the shell or tubes, but remains in the boilers in a state resembling sand, which may be easily removed by washing. There are no long pipes to be supported or to give trouble by jarring the connections loose; no strains due to expansion and contraction produced by the impingement of the feed water against the sheets can take place; the air and carbonic oxide gas that are invariably contained in the feed water, if not expelled in the feed-water heater escapes at once into the steam space without opportunity to cause corrosive action on the shell or tubes. The usual location of this type of feed for horizontal return-tubular boilers is near the front end, as shown in the illustration.

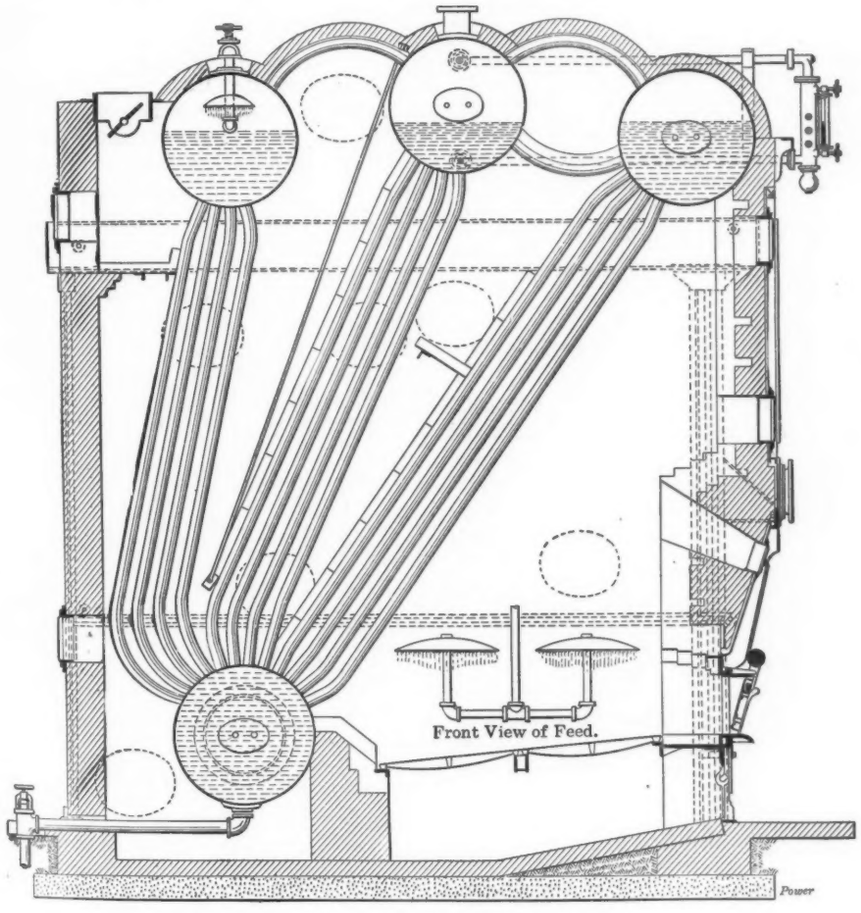


Fig. 15

Vertical Boiler Feeding

The small vertical tubular boiler used for hoisting engines, etc., is generally fed in the water leg, as illustrated in Fig. 10; this is, however, not a desirable location, for it causes severe strains in the furnace sheets, sometimes cracking them, as well as frequently developing trouble with the stay bolts in the vicinity of the feed discharge. There was an idea prevalent at one time, although it is apparently not so widespread now, that a boiler must be fed at the lowest point of the water space, and this has undoubtedly been responsible for the frequent feeding of the vertical and locomotive types of boiler in the water leg. The writer has met engineers who thought it a physical impossibility to introduce feed water in the steam space or near the water line of a boiler.

The proper place to feed the vertical tubular boiler is in the barrel, well above the crown sheet, and if practicable an internal feed pipe should be used projecting between the tubes, so that the feed water may mingle with the rapidly ascending current of water, and become thoroughly mixed with it before it can reach the furnace sheets. Sometimes this pipe is extended entirely across the shell and supported by a plug in the opposite side, the pipe being slotted along the top and bottom sides for the outlet of the water, as illustrated in Fig. 11. While this arrangement is very satisfactory, and is all that could be desired as a method of introducing the feed water, it is liable to stoppage and is not readily cleared. The writer prefers the internal pipe to extend to the center of the boiler only, as illustrated in Fig. 12, and, with a tee placed as shown, the outer end can be plugged, and by removing this plug the pipe can be cleaned by running a rod or scraper through it, which of course cannot be done with the slotted pipe.

Locomotive Boiler Feed

The locomotive type of stationary boiler is frequently fed in the water leg through the blowoff connection, which is usually located at the rear of the furnace, as illustrated in Fig. 13. This is a poor location for the feed, for the same reasons that the water leg of a vertical tubular boiler is not desirable. The locomotive type of boiler can be fed at practically any point in the barrel, or front head below the water line; or if the boiler is of large size, and equipped with a manhole in the top of the shell, a steam-space feed may be used to advantage.

Water-Tube Boiler Feed

The Heine water-tube boiler uses a feed pan located in the steam drum as

illustrated in Fig. 14, the idea being to catch most of the sediment and scale-forming matter in this pan before it enters the boiler. The pan is provided with a blowoff pipe to remove the deposit thus caught. This pan is very effective with some classes of feed water that contain large quantities of suspended matter. The Stirling boiler is usually supplied with a steam-space umbrella feed, as illustrated in Fig. 15, which is practically the same as the Ford feed, mentioned for tubular boilers. The Babcock & Wilcox water-tube boilers are generally fed through the front head of the steam drums, an internal pipe being used to carry the water well back of the front row of headers.

In the installation of all forms of feed requiring an internal pipe, like the Hartford feed, the pipe should never be allowed to rest on the tubes, or any other portion of the boiler; for the constant jarring of the pipe caused by the pulsations of the feed pump, will prevent the formation of a protecting coating of scale at the points of contact, and corrosive properties of the feed water that might never be noted under ordinary circumstances, will readily attack the metal at such points.

Uncle Pegleg's Philosophy

In Which My Trap for the Old Man Don't Work, and I Find out Some Things about Horsepower and the Great Amount of Waste in Burning Coal

"Say, what's this you was giving me about a pound of coal lifting itself two thousand miles high?" I asked Uncle Pegleg the next day. I wasn't at all satisfied that the old man was not either imposing upon my credulity or a little carried away with his solitary musings.

"I told you," he said, "that it had energy enough stored up in it to carry its own weight a couple of thousand miles high."

I had been reading up in the meantime and I thought I had the old man dead to rights. I found a statement in a paper that it was a good plant that would run on three pounds of coal per horsepower and I knew that a horsepower was 33,000 foot-pounds. According to this, then, the pound of coal would do only 11,000 foot-pounds, which was one pound lifted two miles instead of two thousand. I made up my mind the old man had dropped a handful of decimals on his old guessing stick.

"How much coal does it take to make a horsepower?" I asked.

"For how long? It takes ten times as much coal to keep an engine going ten hours as it does one hour with the same load."

"How long will three pounds of good coal run a horsepower?"

"About an hour."

"Then," I said, starting to drive him into his corner, "each pound would do 11,000 foot-pounds of work, wouldn't it?"

"How so?"

"Why, a horsepower is 33,000 foot-pounds, isn't it?"

"Yes, *per minute.*"

"What do you mean 'per minute'? A horsepower's a horsepower, isn't it?"

"Suppose you had a million pounds of water to lift a hundred feet, how big a pump would you put in to do it?" asked Pegleg.

"Yes, but what's that got to do with horsepower?" I had him on the run and I wasn't going to let him get off by quibbling.

"A mighty small horsepower of a pump would lift it *if you gave it time enough,* wouldn't it? If you had to get it up there *in a minute* it would take a pretty good sized pump."

He waited a minute for it to soak in and then continued:

"You measure energy in foot-pounds or any units of space and force, inch-tons, kilogram-meters, because energy is the product of space and force. Power is energy divided by time, and is expressed in foot-pounds or any other of the energy units *per second, per minute* or *per hour,* or per any other unit of time. A horsepower is 33,000 foot-pounds *per minute,* which is

$$33{,}000 \div 60 = 550 \text{ foot-pounds per second}$$

or

$$33{,}000 \times 60 = 1{,}980{,}000 \text{ foot-pounds per hour,}$$

and you can see that while 1,980,000 foot-pounds per hour is the same *rate* of doing work as 550 foot-pounds per second, and, therefore, the same horsepower, it would take 3600 times as much coal to do the 1,980,000 as the 550 foot-pounds; that is to say, it would take 3600 times as much coal to run a horsepower for one hour as for one second."

This was somewhat different but it didn't seem to me yet that there was enough difference to take up all the slack between that two miles and the two thousand. "Let's see," says I. "If it takes three pounds of coal to run one horsepower one hour, and a horsepower is 33,000 foot-pounds per minute, then each pound of coal does

$$\frac{33{,}000 \times 60}{3} = 660{,}000 \text{ foot pounds.}$$

Am I right?"

"You are right," responded my victim, with a pass of the slide up and down his slide rule.

"Well, that isn't any two thousand miles by a jugful," I said triumphantly.

"How many miles is it? Let's see, 5280 feet to the mile, something like 125, eh?" says Pegleg, squinting at the slide rule.

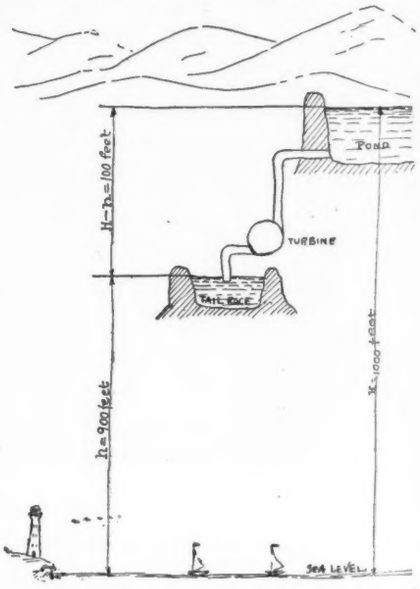
I worked it out rather more laboriously as follows:

$$5280 \overline{)\,660000\,} \quad 125 \text{ miles}$$

5280
13200
10560
26400
26400
00000

"Well, now," he said, apparently not at all disturbed by my demonstration, "that's sort of astounding even at that, isn't it? To think that even with a crude outfit such as we can make we can *actually get* enough energy out of a pound of this stuff to carry its own weight to a hight of 125 MILES."

The old man was so lost in wonder over the demonstrated attainment that it was a shame to press my advantage. Nevertheless I ventured, "But that's only about one-sixteenth of the two thousand miles you said it would lift itself."



Uncle Pegleg reached for a pad and drew this sketch, explaining as he went along: "Here is a mill pond and it is a thousand feet above the level of the sea. The surface of the tail-race is 900 feet above the sea level, and this is the most fall that you can possibly get owing to the lay of the land, anywhere near the

pond. Now a pound of water in the pond has 1000 foot-pounds of this 'potential' energy that we were talking about yesterday, this energy of position, stored up in it, but if the turbine is a *perfect machine* —100 per cent. efficiency—it can get only 100 foot-pounds out of it with the fall that you've got. The pound of water will still have 900 foot-pounds of energy in it when the turbine lets it drop into the tail-race, but you can't get them out because you have no lower level that you can work it to. The land slopes off too gradually all around. What per cent. of the total energy did this arrangement get out?"

"Ten."

"How did you figure it?"

"Why, 100 saved out of 1000 total is one-tenth, and one-tenth is 10 in every 100, or 10 per cent."

"How did you get the 100?"

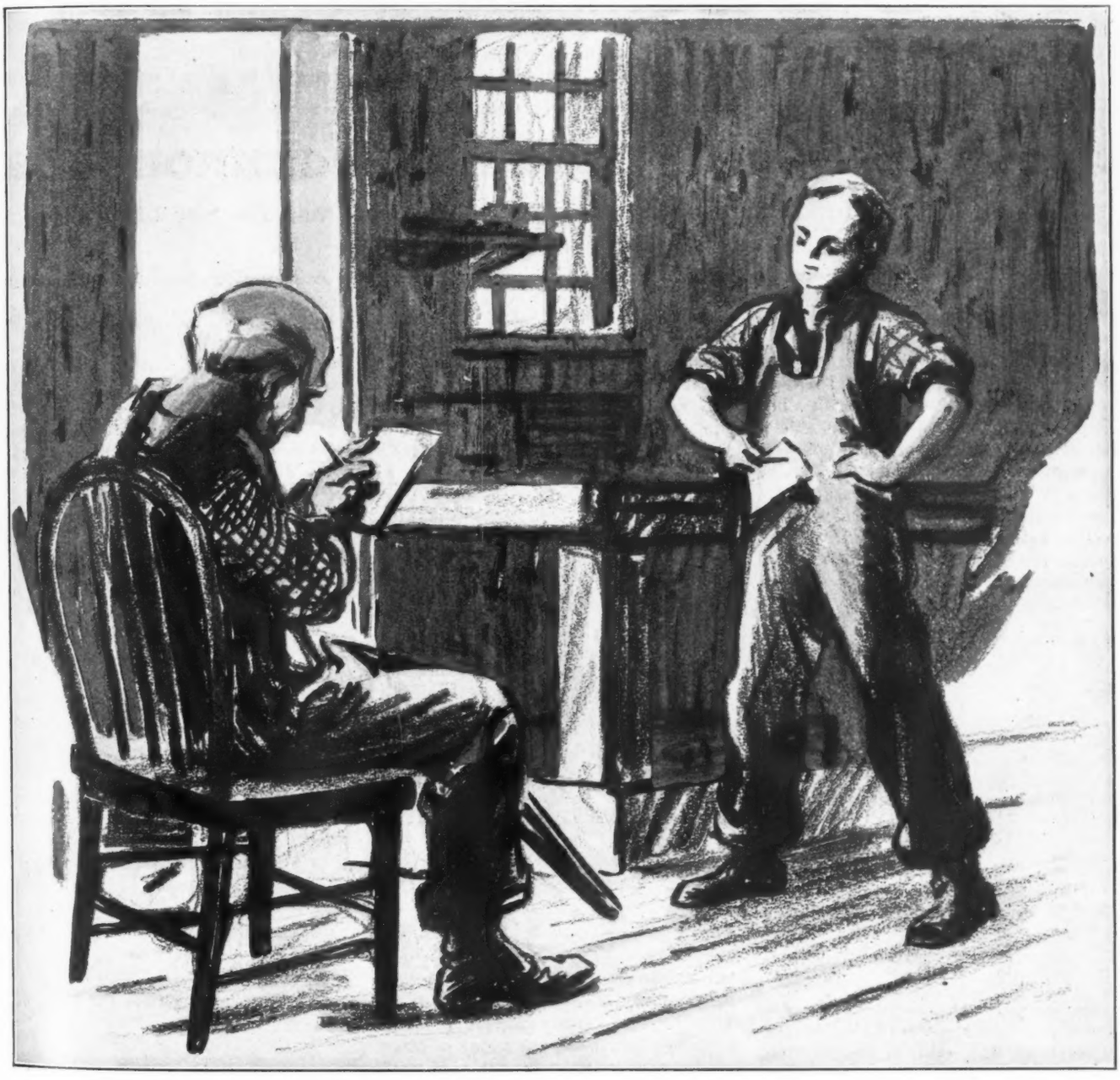
"Subtracted the lower level from the higher."

"Good! And then divided by the higher to get the efficiency:

$$E = \frac{H - h}{H} = \frac{1000 - 900}{1000} = 0.1$$

"No, that's no algebra. That is only what you have just done, subtracted the lower head h from the higher head H, and then divided by the higher head, and this represents the greatest possible efficiency E that can be gotten even by a perfect machine out of that water working through that range of fall—one-tenth of the energy in it when $H = 1000$ and $h = 900$.

"The steam engine," continued Uncle Pegleg, "runs by working heat between different levels of temperature, just as a water wheel does by working water between different levels of hight. The sea level of temperature is what they call the 'absolute zero,' some 460 degrees below the zero of the Fahrenheit scale. What's the temperature of 100-pound steam?"



"I Had Him on the Run and Wasn't Going to Let Him Get off by Quibbling."

I reached him his "Bible" and he showed me that steam of 100 pounds absolute pressure had a temperature, according to the table, of 328 degrees Fahrenheit.

"The lowest temperature level that we can work it to would be that of the condenser, say 110 degrees. Now add 460

to each of them and you have your high and low temperature levels above absolute zero, your pond and tail-race levels for the heat:

$$E = \frac{328 + 460}{788} \quad \frac{110 + 460}{570 = t}$$

Now do the same with these as you did with the water, calling the high temperature T and the low t:

$$E = \frac{T - t}{T} = \frac{788 - 570}{788}$$

Work that out."

I passed him over the following:

$$\begin{array}{r} 788 \\ 570 \\ \hline 788 \,)\, 218.000 \,(\, 0.276 \\ 1576 \\ \hline 6040 \\ 5516 \\ \hline 5340 \\ 4728 \end{array}$$

"Good," said he. "So you see that under those conditions we could get out only 0.276 of the total energy even if we had perfect engines and boilers. That is only a little over a quarter, and that cuts my sixteen times too much down to about four times too much, eh? Well, three pounds of coal is about four times too much for a perfect engine working between those temperatures, so when you come to figure it out precise I guess you will find the old man was pretty near right?"

"How do you figure it out precise?" I asked.

"I'll show you some day. There's a thing or two you've got to learn first—not so much either," answered Uncle Pegleg as he packed up his dinner pail.

Steam Heating Systems in Common Use

Their Adaptability to Certain Classes of Work, with Tables Giving the Size of Pipe to Supply a Given Amount of Radiation

BY J. P. LISK

There are many complicated problems to be worked out by the designer of efficient and economical piping for steam and hot-water heating systems. To accomplish these ends the designer must have, not only intelligence and theoretical ability, but several years of practical experience in the work of erecting and operating high-, low-pressure, and vacuum heating plants. These might as well be called pressure systems, with absolute-zero pressure, as the base from which to calculate, instead of the variable atmospheric line, now erroneously and unintelligently used. The zero of pressure is vacuum, and anything above vacuum is pressure and any system of steam heating that works at all works with some pressure, and that pressure must be calculated from some point, and that point has been, until recent years, taken at the pressure of the atmosphere, or 14.7 pounds absolute pressure.

TABLE 1

Nominal Inside Diam. of Pipe.	Square Feet of Direct Radiating Surface Supplied with Steam at One Pound Pressure above Atmosphere.		
	Two Pipe System for Steam.	One Pipe System for Steam.	Hot Water System, Water at 180° in Boiler.
¾"	21	18	17
1	36	32	29
1¼	90	79	72
1½	130	115	104
2	225	198	180
2½	510	450	408
3	730	640	584
3½	1,150	1,080	800
4	1,600	1,410	1,280
4½	2,050	1,805	1,640
5	2,500	2,200	2,000
6	4,200	3,700	3,360
7	7,100	6,250	5,680
8	9,300	8,200	7,440
9	12,200	11,725	9,760
10	15,700	13,800	12,560
12	22,600	19,900	18,080

Absolute vs. Gage Pressure

Now there is a large difference in steam of one pound absolute pressure and one pound gage pressure as the following example, taken from a steam table in general use, will show in a very practical manner. One pound of steam at one pound absolute pressure has a temperature of 102 degrees Fahrenheit, a latent heat of 1,043.015 B.t.u.; or a total heat above 32 degrees Fahrenheit of 113.055 B.t.u., and a volume of 330.4 cubic feet; while say one pound of steam at 16 pounds absolute pressure (this figure is taken for convenience of comparison) has a temperature of 216.347 degrees Fahrenheit, a latent heat of 962.7 B.t.u., or a total heat above 32 degrees Fahrenheit of 1147.926 B.t.u., and a volume of 24.33 cubic feet. At 26 pounds absolute, or 10 pounds gage, we have a temperature of 242.225 degrees Fahrenheit, a latent heat of 944.73 B.t.u., or a total heat above 32 degrees Fahrenheit of 1155.819 B.t.u., and a volume of 15.42 cubic feet. Of course, it would be a practical impossibility to design and erect a system of heating that would work with only one pound absolute pressure, that figure being given for comparison only. Now take a practical working pressure of 10 pounds absolute and compare it with a working pressure of 16 pounds absolute; we have the following quantities to consider:

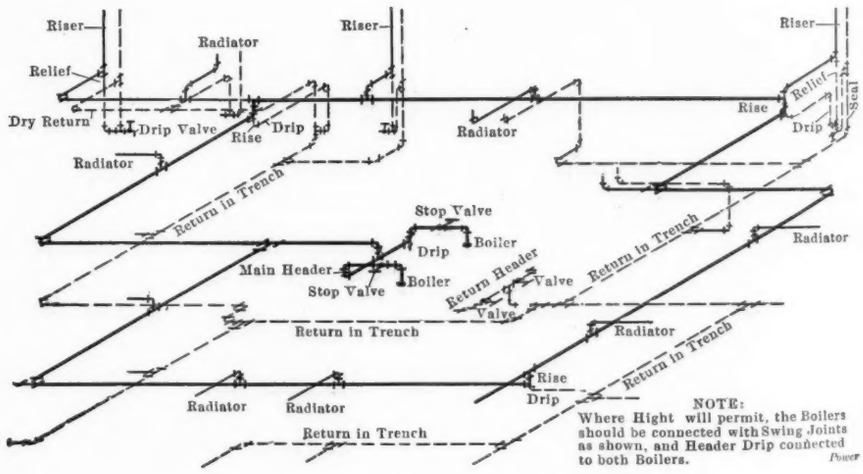


FIG. 1. TWO-PIPE SYSTEM

Absolute Pressure.	Temperature.	Latent Heat.	Total Heat Above 32° F.	Volume, Cu.Ft.
10	193.284	979.232	1140.892	37.83
16	216.347	963.007	1147.926	24.33
Difference.	23.063	16.225	7.034	13.50

Particular attention is called to the heat units and the volume. With the given pressure below atmosphere we have gained 16.225 B.t.u. per pound in

latent heat that will be given out through the radiating surfaces, but the volume of steam to be handled in the piping system has been increasing by 13.5 cubic feet per pound.

To further illustrate what this actually means in the design of a system of

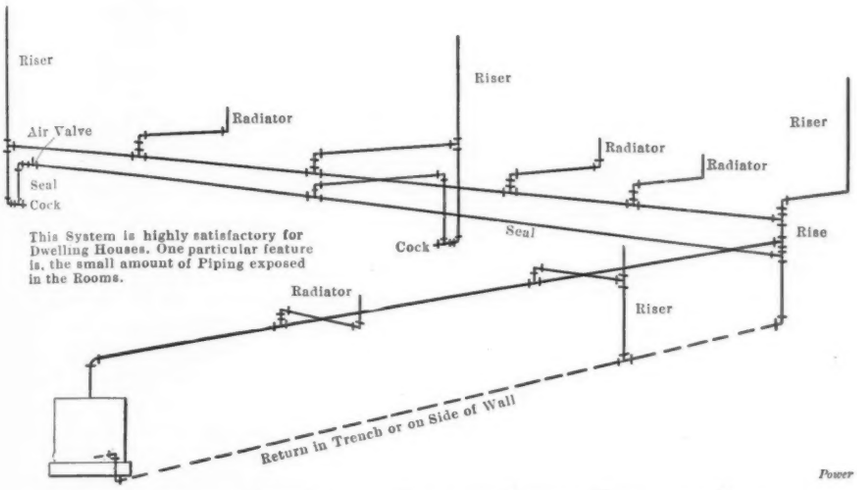


FIG. 2. ONE-PIPE SYSTEM WITH SEPARATE RETURN PIPE FROM MAIN

piping, let us consider the volume of steam necessary to supply a radiator under the ordinary conditions of service, that is, with a pressure of 16 pounds absolute or 1.3 pounds above atmosphere. Assuming that one square foot of surface will transmit 1.75 heat units per degree difference between the temperature of the steam in the radiator and the temperature of the air in contact with the outside, we have

$$(216.347 - 62) \times 1.75 = 270$$

B.t.u. per hour, corresponding to a volume of 6.82 cubic feet per hour for each square foot of surface. Following the same order for 10 pounds absolute we have

$$(193.284 - 62) \times 1.75 = 229.75$$

B.t.u. per hour, corresponding to a volume of 8.87 cubic feet per hour for each square foot of surface, or a difference of 2.05 cubic feet, an increase of 30 per cent. in volume, and a decrease in heat units transmitted per square foot per hour of 14.9 per cent.

These figures would make it appear that pressures below the atmosphere are undesirable in systems of steam heating, but such is not the case, as there are many advantages to be gained in operating at low pressure, and consequently low temperatures, but they would not be revelant to the present subject.

CIRCULATION

The next step is the principle of circulation and the laws governing it; the first is, that there shall be a difference in pressure between the source of supply and the thing supplied, and the greater the difference the more rapid the circulation.

This law is fundamental in hydraulic, pneumatic and steam engineering and furnishes a basis from which our calculation may be made with great accuracy under conditions where the friction of the duct, or pipe, and the nature of the substances in transit is known. Each square foot of radiating surface requires a certain volume of steam per hour to keep it in operation, and the volume quoted for 16 pounds absolute pressure is 6.82 cubic feet. If this steam were all condensed, as it is supposed to be, and no more steam came in, we would eventually have a vacuum in the radiator, but, as the steam in the boiler is at a constant pressure and in the radiator it is constantly losing pressure by giving up its heat, it will naturally flow through the pipe in a sufficient quantity to make up the loss in volume required to maintain a certain pressure, providing the pipe is large enough.

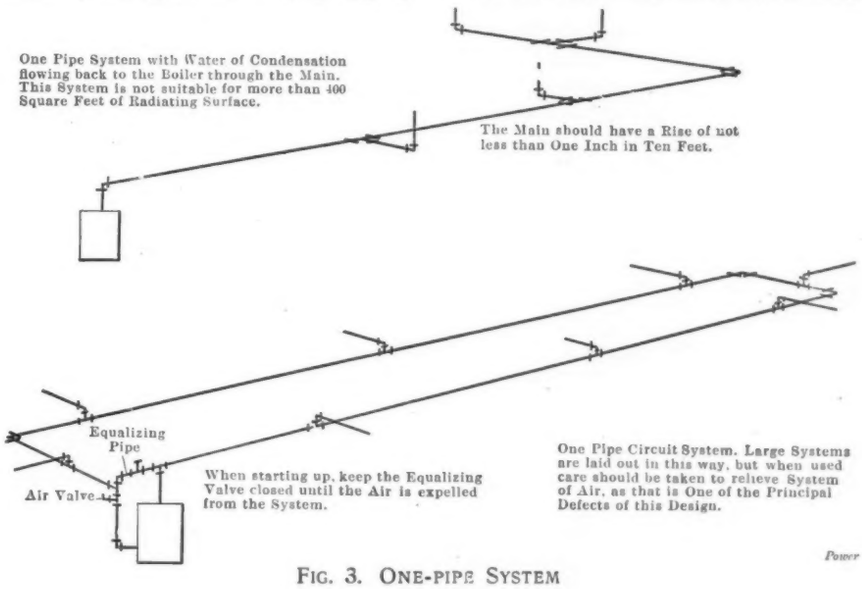

One Pipe System with Water of Condensation flowing back to the Boiler through the Main. This System is not suitable for more than 400 Square Feet of Radiating Surface.
The Main should have a Rise of not less than One Inch in Ten Feet.
Equalizing Pipe
Air Valve
When starting up, keep the Equalizing Valve closed until the Air is expelled from the System.
One Pipe Circuit System. Large Systems are laid out in this way, but when used care should be taken to relieve System of Air, as that is One of the Principal Defects of this Design.
Power

FIG. 3. ONE-PIPE SYSTEM

FLOW OF STEAM THROUGH PIPE

Mr. Babcock's formula for the approximate weight of any fluid which will flow in one minute through any given pipe with a given head or pressure is as follows.*

$$W = 87\sqrt{\frac{D\,(P_1 - P_2)\,d^5}{L\left(1 + \frac{3.6}{d}\right)}}$$

In which

W = Weight in pounds avoirdupois;
d = Diameter in inches;
P_1 = Initial pressure;
D = Density or weight per cubic foot;
P_2 = Pressure at the end of the pipe;
L = Length of the pipe in feet.

There are several points in the data referred to in connection with this formula to which I will call attention. First, the results arrived at, noted by Mr. Babcock as approximate, are very close to the actual quantity delivered. Second, the pipes are supposed to be straight and smooth, how smooth and how straight is a matter to be determined by experiment. Commercial pipe is not very smooth, as that term is commonly understood. Third, elbows are made with a radius from a sharp right-angle turn to six diameters; the resistance, therefore, varying with the radius, must be determined for each particular radius used. The fact is, no formula can be derived from data taken from one installation that will exactly apply to the design of some other installation, although the conditions of service are practically the same; however, with the assistance of various formulas, and the results of carefully made experiments, a table of sizes for given amounts of radiation may be compiled that will be accurate enough for all practical purposes, and when we consider the wide difference in carrying capacity of the

*See *Steam*, page 99, for data pertaining to flow of steam through pipes based on this formula.

various-sized pipes, and the slight difference in cost between any two sizes, we are justified in using an authenticated table (together with our experience-bought judgment and our knowledge of the conditions under which the plant we are studying will work) in designing our piping systems.

The following experience is cited as an illustration of how some very elaborate calculations on a line of pipe 321 feet long worked out. I superintended the erection of this line, and took particular care to have everything erected exactly as the designers wished. They had decided on a minimum drop of two pounds pressure between the supply and discharge ends, and made all their calculations accordingly. The initial pressure was five pounds and the terminal pressure three pounds per square inch. I watched that line all one winter, and there was never a time when two calibrated gages showed a greater difference than 0.45 of a pound, and it was a rare occurrence when more than two pounds pressure was required at the reducing valve in the boiler room.

One of these men is one of the foremost mathematicians in this country and the other is a steam engineer of exceptional ability and large experience in heating and ventilating work. In discussing the matter in detail they said they were not surprised at the results, and if they had similar conditions to meet in another installation, they would use the same size pipe, rather than chance a failure by reducing to the next smaller size. All engineering problems may be solved in that manner, provided we have all, and absolutely reliable, data involved in the problem to work with. In many problems such data are to be had, but in the piping work of a steam or hot-water heating system they are impossible to obtain, for the simple reason that they would have to be worked out from tests of the system, and the results obtained from the tests of one system are only applicable in a general way to the design of a similar system.

I have compiled Table 1 from a large number of tests of systems personally designed and installed, that have been working in a highly satisfactory manner and from a commercial standpoint the table is reasonably correct.

Piping Systems

Briefly I will describe the several systems of piping in common use and their adaptability to certain classes of work. The two-pipe system is universally used for large systems of 15,000 square feet and over, and quite generally for systems down to 1000 square feet. The advantages are, a minimum size for supply and return pipes, the reason for this being that the water of condensation is always flowing in the same direction as the steam, thereby preventing water hammer, reducing friction, insuring positive and rapid circulation, and ability to work well through a wide range of pressure. This system is shown in Fig. 1.

The two-pipe main, and one-pipe riser system, sometimes called the one-pipe relieved system, is composed of a supply pipe running from the boiler to the bottom of the riser, through which the steam and water of condensation from the first-floor radiators flow to a low point and run through a separate return pipe to the boiler. The radiators above the first floor are supplied with steam through a single pipe connection, the water of condensation passing back through the same pipe. This system is shown in Fig. 2.

The purely one-pipe system consists of a single pipe of large size running from the top of the boiler to the radiators and returning the water of condensation through the same pipe. This system and its modified form are shown in Fig. 3. The modification consists of a change in the direction in which the pipe is pitched and its continuation in the form of a loop back to the bottom of the boiler. This system in either form works well when the pipes are large enough, but, when that is the case, they cost just as much to install as the system shown in Fig. 2, consequently there is no particular advantage in its use, except as a matter of convenience in erection under certain conditions.

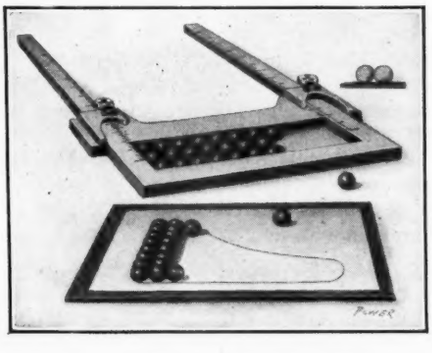
The arrangement and size of return pipes present a more difficult problem for solution by scientific methods than the supply pipes; and we have very few reliable data at hand bearing on that part of the work. Every engineer seems to have a method of his own by which he determines the size of his return pipes, and the answer generally given to a request for information is that it is simply a matter of judgment, and when we take into consideration that some return pipes have steam, water and air passing through them, called dry return, while others have water only, but are so located that circulation is very sluggish, and still others are in a vertical position which offers slight resistance to the passage of their contents, it is easily understood that a rule or formula to be of any practical use, would have to be derived for each condition of operation. The following table gives my own general practice so far as I am able to put it into figures, showing the size of return pipes to be used in low-pressure steam heating.

If the accompanying tables are used to determine the size of piping for a given amount of radiation, a good working job will be had, providing grade, drip and workmanship are all right. I have made no distinction between wet and dry return, leaving that to the judgment of the designer; neither have I mentioned the down-feed system because I believe any man who is capable of designing an up-feed system will have very little trouble in working out his design, with the main in the attic, when conditions require such an arrangement. In my practice I avoid everything in the line of freak construction, and have refrained from mentioning or showing any of the details of such systems, as there is little, if any, profit in discussing things that are apparently not controlled by natural laws.

TABLE 2. SIZE OF RETURN PIPES.

Size of Supply Pipe.	¾″	1″	1¼″	1½″	2″	2½″	3″	3½″	4″	4½″	5″	6″	7″	8″	10″	12″
Two-pipe system	¾	¾	1	1	1¼	1¼	1½	2	2	2½	2½	3	3	4	4	5
One-pipe relieved system	¾	¾	1	1¼	1¼	1½	2	2½	2½	3	3	3	3½	5	6	6
One-pipe circuit	¾	¾	1¼	1¼	1½	2	2	2½	2½	3	3					
Risers		¾	1	1	1	1¼	1¼	1½	2	2½	2½					

Finding Area of Surfaces



A very unique method of finding the area of surfaces with irregular boundaries was pictured in the *Scientific American*. It comprises a flat steel plate that is magnetized, and hence becomes a permanent magnet, and a number of soft iron balls. The size of the plate depends upon the dimensions of the area to be measured. The drawing on which the area is outlined is placed over the plate, and to protect the drawing a thin piece of paper is placed over it. The area outlined is then filled with the iron balls, which are flat on the under side to prevent them from rolling. The magnetized plate converts the balls into temporary

magnets, causing them to cling to the plate and to each other. After the area of the drawing is filled, the balls are taken out and placed in a measuring frame, as indicated in the engraving, and the number of square inches occupied by the balls is ascertained. Tables are furnished which permit of reducing the square inches thus found to the scale of the drawing, thus giving the area sought without any calculation. It will be observed that the side members of the measuring frame are calibrated, and the sliding crossbar is provided with vernier scales, so that the area occupied by the balls may be obtained with exactitude. The ease with which any given area can be set on first trial should make this apparatus valuable to engineers and surveyors. The apparatus is adaptable to irregular as well as regular surfaces. The inventor of the area finder is Alfred C Freeman who is a resident of Norfolk, Va.

Large Centrifugal Boiler Feed Pump

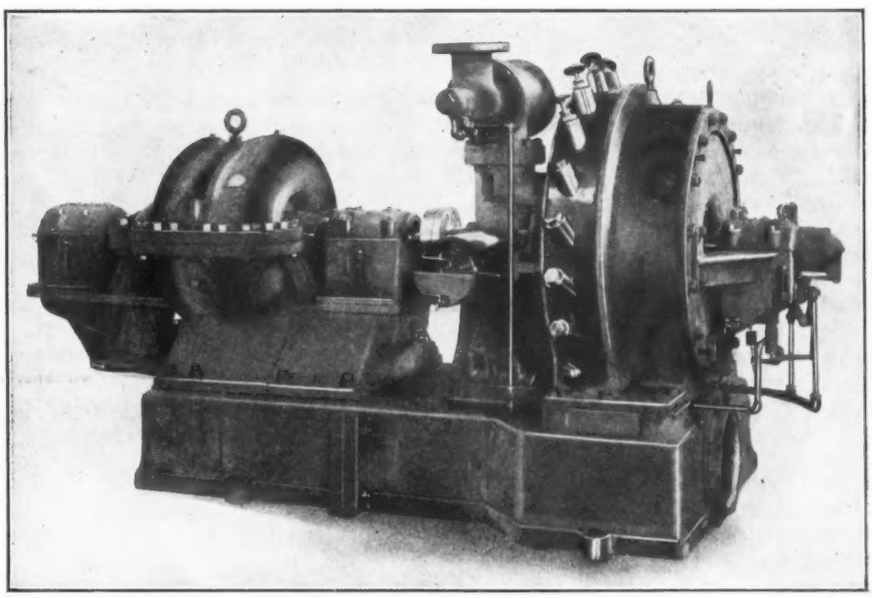
Reported to Be Largest Individual Turbine-driven Unit Made in This Country for Boiler Feeding. Has Normal Capacity of 25,000 Boiler Horsepower

BY H. Y. HADEN

The past year or so has seen a large development of the steam turbine-driven centrifugal pump for boiler-feed purposes and it is now common practice among power-plant engineers to specify steam turbine-driven pumps for feeding boilers where the water quantity required under normal conditions is not less than approximately 100 to 150 gallons per minute. The greater simplicity of a turbine-driven centrifugal over the reciprocating plunger pump with its complication of parts and sometimes heavy upkeep in the way of renewals of packing, valves, etc., is probably the main reason that the rotary boiler feeder has come so rapidly into service. The absence of shock in the discharge from a centrifugal and the ability to obtain close regulation on both the turbine and pump, are also favorable features of this type of unit. Another advantage is in the method of lubrication, which in the case of the centrifugal boiler-feed pump is carried on automatically in ring-oiled bearings, and therefore the amount of oil consumed by the unit is negligible. The absence of any cylinder-oil lubrication and the difficulties attending this where there is considerable superheat present is also overcome. Furthermore, the exhaust from the turbine having no oil in it, can be taken direct to the feed-water heater without any oil-purifying device.

The steam turbine-driven centrifugal pump illustrated below is perhaps of unusual interest as we believe it is the largest individual turbine-driven unit as yet manufactured in this country for the purpose of boiler feeding, having a normal capacity for feeding 25,000 boiler horsepower. It is also interesting from the fact that the pump end is a two-stage centrifugal although the total head to be overcome is 300 pounds. A few years ago, centrifugal-pump manufacturers would have claimed that 150 pounds or 350 feet per stage would be entirely impossible for any centrifugal pump to handle, but long experience and a thorough knowledge of the true design of impellers have proved that it is possible to build centrifugal pumps that will operate successfully and with high efficiency when pumping against very high heads per stage, as in the case of the boiler-feed pump under discussion. The advantages of a two-stage pump over a four- or five-stage unit to do the same work are obvious, namely, a simpler unit throughout with consequent less upkeep and lower first cost. It has been the aim of the builders of this unit to make it as simple as possible without sacrificing efficiency, and with this in view, the pump has been designed so that all parts coming in contact with the liquid to be pumped and consequently subject to wear, can be readily and quickly examined and renewed if necessary, all parts being interchangeable. With a view also toward simplifying the pump case, diffusion vanes have been eliminated, it having been claimed that with a properly designed pump wheel, diffusion vanes do not increase the efficiency. The turbine end is also a two-stage unit of the simplest construction, designed to develop 450 brake horsepower when operating at 2800 revolutions per minute and taking steam at 200 pounds boiler pressure exhausting into a heater. The normal capacity of the pump is 1600 gallons per minute. Particular pains were taken to design the pump with a very flat characteristic so as to enable the unit to operate successfully when feeding a small proportion of the normal boiler load, 25,000 boiler horsepower.

The pump is equipped with a marine-type thrust bearing which is designed to take care of thrusts which may develop due to the varying discharge. Under normal conditions of operation, the impellers are self-balanced. The turbine is equipped with two governors, a regular throttling governor geared from the main shaft and a trip or safety governor which comes into service automatically should the turbine for any reason commence to run away.



TURBINE-DRIVEN TWO-STAGE CENTRIFUGAL BOILER-FEED PUMP

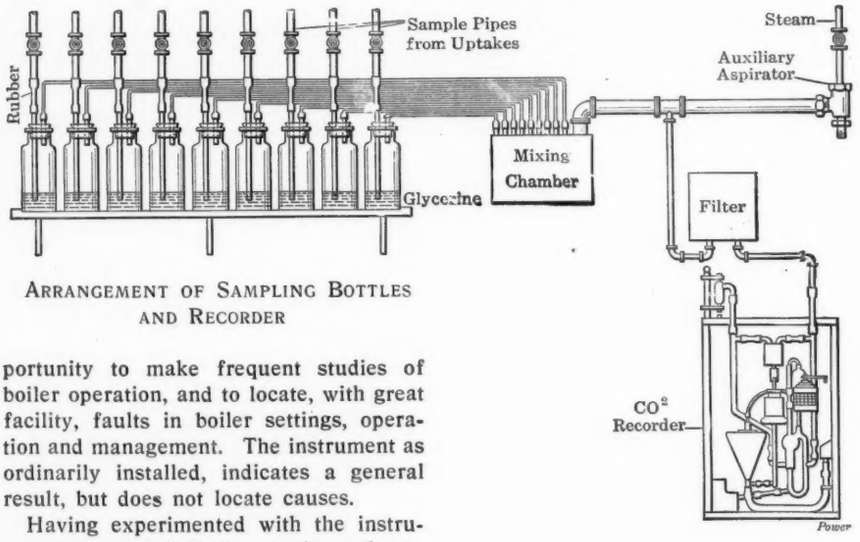
The unit above described is one of two operating at the Detroit Edison plant, of Detroit, Mich., and was manufactured by the De Laval Steam Turbine Company, of Trenton, N. J., and installed by the Turbine Equipment Company, of New York City.

How to Use CO_2 Apparatus in Boiler Room

BY WARREN B. LEWIS

The making and keeping of accurate records of gas analysis have demonstrated the value of studying the CO_2 phase of boiler operation. The instrument and its accessories are reliable, and when given the care and attention which the more or less delicate apparatus deserves, the results obtained are both consistent and highly satisfactory.

There is one phase of the subject which has not been very freely discussed, namely, the use of the instrument, both as a continuously recording instrument and as a testing instrument for periodical use. The CO_2 recorder affords an opportunity to make frequent studies of boiler operation, and to locate, with great facility, faults in boiler settings, operation and management. The instrument as ordinarily installed, indicates a general result, but does not locate causes.



ARRANGEMENT OF SAMPLING BOTTLES AND RECORDER

Having experimented with the instrument over a period of several months, to determine its greatest usefulness, the writer offers a brief description of his experience in the hope that it will suggest new and more complete uses to those who have heretofore considered the instrument as more or less limited in its application.

INSTALLING THE RECORDER

The usual method of installation is to locate a sample pipe in the main flue, and obtain samples of the gases before they pass to the chimney. It has been the experience of many that this is not as simple as it sounds. The record made is not true of the conditions which exist within the boiler settings, and does not locate faults. If one boiler is being repaired, and more or less air is passing through the setting, the record is destroyed, and does not indicate what the boilers are doing. If at night, a number of fires are banked, the record is again incorrect. If a number of firemen are employed, it is impossible to tell which man is firing correctly and which incorrectly; and it is only fair that the man who does the best work should receive credit whether in the form of a bonus in money, or in any other form.

The method employed by the writer has been to make each boiler independent of the others, so that at any time a record may be taken from any one boiler, any group of boilers, or the whole plant. The boilers not in operation are disconnected, and the air leaks exterior to the boiler setting have no influence upon the accuracy of the record.

A description is given of the apparatus as installed in a plant of nine boilers, five of which are rated at 200 horsepower each; and the other four, horizontal return tubular, rated at 250 horsepower each. The uptakes of these boilers connect to one main flue, the gases passing through an economizer to the chimney. A mixture of buckwheat and bituminous coal is used in the proportion of three to one, and forced draft is employed, the chimney merely taking the gases away from the furnaces.

As usually operated, there is a draft of about 1/10-inch in the furnaces, just sufficient to prevent the gases being blown out of the fire doors when the latter are opened. The boilers are operated at considerable overloads for about twelve hours a day, and through the night from one-third to one-half of the boilers are operated slightly below rating, while the others are cut out of service.

A CO_2 recorder was installed in a cabinet having a glass door, and this cabinet was kept locked, the key being in the possession of the engineer. The firemen could observe the records made and be governed accordingly; but the care of the instrument was entirely in the hands of the engineer, who was responsible for its condition. The sketch illustrates the arrangement of piping and apparatus.

In the uptake of each boiler, immediately below the hand damper, a sample pipe was placed, and extended, by means of a ¾-inch iron pipe, to one end of the boiler room and near the CO_2 recorder. The nine pipes were brought to this common point, and each provided with a valve. Nine 16-ounce bottles were placed on a shelf, each bottle being provided with a rubber stopper through which two glass tubes were tightly fitted, one tube ending immediately below the stopper, and the other tube extending down to within an inch of the bottom. In each bottle a sufficient amount of glycerin was introduced to seal the end of the longer ½-inch pipe.

The longer tube in each case was connected with a sample pipe by means of a rubber tube. From the nine short tubes connections were made with pipes to an air-tight copper box or mixing chamber, and from the latter a pipe was run to an auxiliary aspirator, which was simply an ejector, such as is used to prime centrifugal pumps. A small steam pipe from the steam main was connected to an aspirator, and, by means of a valve, the vacuum created in the mixing chamber could be varied at will. It is evident that any draft so produced would draw from the nine bottles; and, in order to produce an equal draft in each bottle, the valves in the sample pipes were operated to produce about an equal amount of bubbling in the glycerin within each bottle, with the assumption that an equal amount of bubbling, as near as could be observed, would represent an equal amount of gas drawn through each sample pipe. From a tee in the pipe between the mixing chamber and the auxiliary aspirator, a ½-inch pipe was run to a cotton filter, and from there to the CO_2 recorder, the aspirator on the latter drawing a sample of gas through the filter. It is, of course, essential that the draft produced by the auxiliary aspirator be not greater than that produced by the aspirator on the recorder, else the latter would not draw a sample.

EXPERIMENTING

Immediately after the apparatus was put into use, a systematic study of one boiler was made to determine what conditions gave the best results. One thing at a time was studied. For instance, other things being disregarded, the best thickness of fire to attain a given result was determined; then the draft pressure beneath the grates; the draft pressure in the furnace, and, finally, a test was made to determine the output of the boiler when the highest CO_2 record was made. It was possible to observe the influence of one condition upon another, and to demon-

strate to the fireman the result of any act which he performed. One of the most noticeable influences was the effect of air leaks in the setting. This was gone over carefully, and every opening calked with asbestos, attention being given particularly to the fronts. After many days of experimenting, it was found possible to obtain records of 12½ and 13 per cent. CO_2, but such records were difficult to maintain under the conditions which existed, in the practical operation of the plant.

Operating

The standard having been set for the first boiler, the second boiler was studied, and here it was found that notwithstanding the operation was made as nearly identical with the first as possible, the record was very bad. It was only after the most detailed inspection on the part of the engineer, that he found an air space in the wall communicating with the outside air, a defect which had existed for a number of years, but never found before.

The second boiler having been brought up to standard, the two boilers were operated in connection with the recorder, and the result noted. The third boiler was then studied, and finally added; and so on until the experimenting had been practically completed.

As a matter of fact, not less than four months was spent in finally establishing permanent conditions of operation, the firemen, meanwhile, having been offered a bonus if the records made averaged 10 per cent. or better. As a matter of fact, records of 12 and 13 per cent. have been made for several hours at a time, with possibly low points resulting from the cleaning of fires. The firemen showed a great interest in the work and continually watched the records, using all their effort and skill to overcome any temporary lowering of the record.

When a boiler is temporarily out of commission, the sample pipe is shut off, and the air allowed to pass through the setting has no effect upon the record from the other boilers. At night the sample pipes from the boilers not in use can be shut off, and the record obtained from the boilers in use remain correct.

As it was found possible to obtain such high records of CO_2, a portable Orsat apparatus was purchased for the purpose of checking the CO_2 instrument at times, and this was found very valuable to correct any tendency toward the production of CO.

It was found desirable to study the work of each man. The three boilers in his care could be connected to the CO_2 recorder independently, the others being temporarily shut off; and this without any preparation or even knowledge on the part of the fireman.

Naturally considerable improvement could be made upon the devices used. Instead of the individual bottles, and a mixing chamber, it might be possible to use a Wolff bottle with any number of necks, the upper part of the bottle serving as the mixing chamber.

It would also appear to be desirable to filter the gases from each sample pipe before they pass to the bottle, as experience showed that considerable soot passed into the glycerin, discoloring it and making the bubbling nearly invisible except on the surface.

Some objection might be offered to the apparent complication of this method of making CO_2 records; but, as a matter of fact, when once installed, the apparatus is very simple.

The apparatus involved in the making of CO_2 records is of an entirely different class than that usually found in a boiler room, and requires considerable skill in its handling. The results are so noticeable, however, that any ordinary cost of time involved is of little account. The present tendency to pay more attention to the cost of production carries with it no greater field of investigation and sure result than in boiler operations, at least as far as the mechanical plant is concerned. The efficiency of most apparatus does not alter greatly from day to day. The efficiency of a boiler plant may vary 20 per cent. almost from hour to hour, and anything which makes it possible to observe, to any degree, the varying conditions, deserves all the attention it requires.

What Causes Chimney Failures?

What are the requisites for permanence and integrity of brickwork in tall brick chimneys? We put this question because we have not been able to get a satisfactory answer by inquiry of expert builders. Sometimes, it seems, an experienced chimney builder erects a stack that proves a failure, a structural failure that is, inasmuch as the brickwork cracks after a short time, without severe exposure, and brings the whole stack into more or less ruinous condition. What causes can be responsible for such disintegration of good brick masonry? Are we to blame the brick, or the mortar, or the mason's workmanship, or the foundation, or swaying, or atmospheric or temperature action? Or must we say we do not know?

The query may be illustrated by two puzzling cases of disintegration in brick chimneys, which came up last summer. The two cases together also furnish negative replies to some of the suppositions just made.

Both stacks were only a few years old (three to six). Both were something over 150 feet high. One was of slender, the other of rather stout proportions. Neither had been used severely; one was really never in regular service, the other had been regularly employed in ordinary nonforced boiler service.

Both stacks were built of radial perforated brick laid in cement-lime-sand mortar. The pressure intensities in the brickwork were not considered excessive, even in hurricane winds. The foundations were satisfactory, one being on concrete on undisturbed clay soil, the other on plate-girder framing between columns in a power station. One of the chimneys was built in summer, the other in winter. Neither showed any tilting or other evidences of integral failure, so far as we can learn.

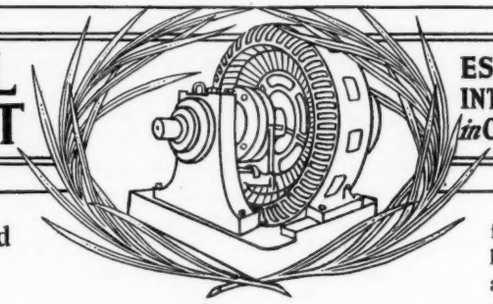
Both chimneys exhibited slow but progressive multiple cracking, partly vertical, partly diagonal. The upper sections of both seemed to be most affected. Both deteriorated so much that they were taken down. Both had to be rebuilt, in short.

What was at fault?

We are also induced to raise the question because of a paper read last fall at Copenhagen before the International Association for Testing Materials. A Dutch professor there set forth the theory that great numbers of failures in brick and stone masonry arise from wrong mortar mixtures. He inveighed specially against cement-lime mortars, claiming them to be destructive agents by action of (1) solution, (2) percolation into the stone or brick, and (3) recrystallization. No actions of the kind he speaks of have yet been reported in this country, so far as we know. But the theory is convenient to explain just such failures as the two above noted. What bearing, if any, has the theory on these cases, and for what reasons? We commend this as well as the earlier question to the attention of engineers who deal much with brickwork. —*Engineering News.*

George W. Melville, engineer in chief of the United States navy, states that there is every reason to believe that two ships of the navy will be fitted with the Melville-Macalpine turbine reduction gear. It is proposed to reëngine the "Baltimore" with turbines of 12,000 horsepower, and equip one of the new colliers with turbines of 6000 horsepower, both employing this gear.

ELECTRICAL DEPARTMENT



ESPECIALLY CONDUCTED *to* BE *of* INTEREST *and* SERVICE *to the* MEN *in* CHARGE *of the* ELECTRICAL EQUIPMENT

High Voltage Transmission and Distribution of Hydro-electric Power at Milwaukee

The Milwaukee Electric Railway and Light Company, operating the city railway system in Milwaukee and many of the interurban lines running out of the city, and supplying the bulk of the commercial power and lighting service in the city, has three generating stations in Milwaukee and, on account of the growth of business and the increasing demand for power, has recently completed the necessary construction to receive additional energy from the Kilbourn falls hydro-electric development. Substations are located at Watertown, Waukesha Beach, East Troy, Burlington and West Allis for transforming this additional power to suit distribution requirements. The West Allis substation, which formerly received its power from the generating plants in Milwaukee for use in West Allis and on the traction lines, has been extended by the addition of a large transformer room for lowering the voltage of the energy received from Kilbourn falls for transmission to the city. The present article deals particularly with the electrical installation there.

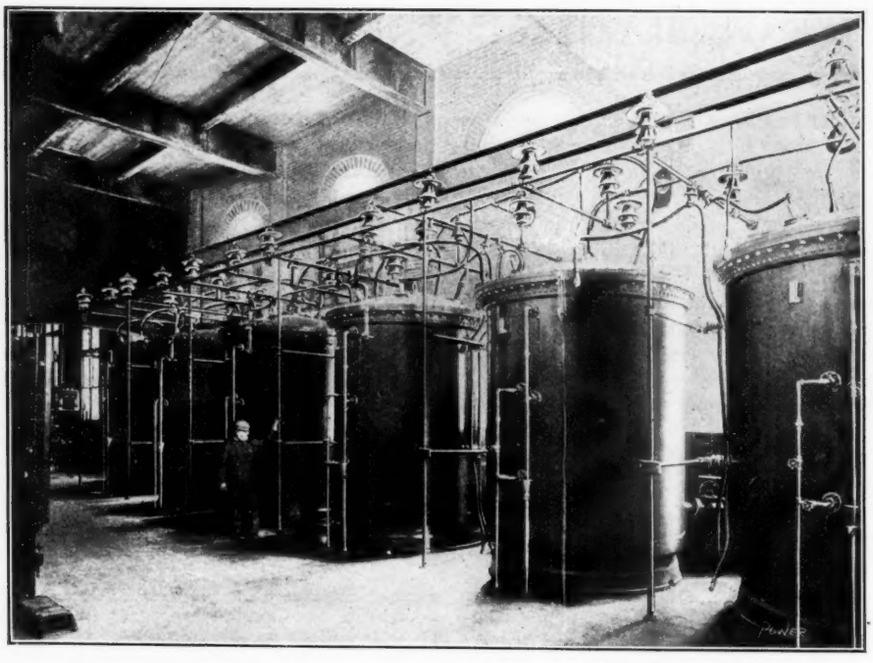


FIG. 1. SIX MAMMOTH TRANSFORMERS

In the design of the transmission lines and substations all parts have been arranged for an ultimate pressure of 66,000 volts and at that voltage the transformers will be connected star fashion. At present, however, the transformers are connected in delta and the line voltage is only 38,100 volts; at this voltage sufficient power can be transmitted for present needs. By changing the pressure to 66,000 volts the power that can be transmitted will be increased or the line losses reduced. This change can be accomplished without other expense or trouble than rearranging the connections of the transformers. Connected in delta and receiving power at 38,100 volts the transformers are arranged to give 13,200 volts at the secondaries. When the voltage of the line is raised to 66,000 volts and the transformers' primaries are connected in star, the secondaries will still give 13,200 volts.

From Kilbourn falls to Watertown, a distance of 67 miles, the wires are No. 0 hard-drawn stranded copper, supported on steel towers which average 550 feet apart. These towers are of the square or windmill type and light structural-steel members are used in their construction. At the base the towers are 12 feet square. They are supported on concrete footings, to which they are firmly bolted, and the footings are carried to a sufficient depth to be free from the influence of frost. The towers are of different hights for varying conditions and are so arranged that the lowest wires are respectively about 40, 50 and 60 feet from the ground. The three wires of each line are carried vertically above each other, and the two lines are 12 feet apart, one line on each side of the tower.

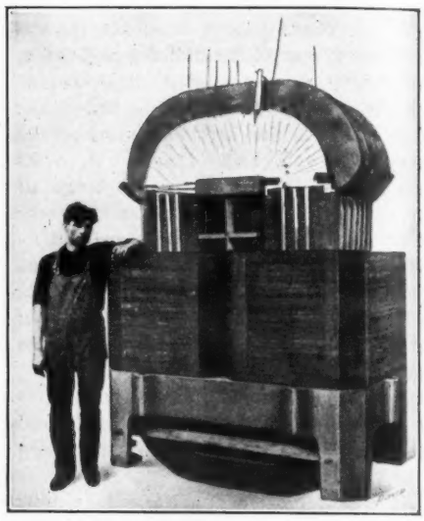


FIG. 2. COILS AND PARTLY ASSEMBLED CORE. NOTE THE RELATIVE SIZE

From Watertown to West Allis, a distance of 43 miles, the wires are No. 000 stranded aluminum, which is the equivalent of single 0 copper. From Watertown to Waukesha Beach the wires are carried 26 miles on a continuation of the tower line (which has a total length of 93 miles), and from Waukesha Beach to West Allis, 17 miles, the wires are carried on a heavy pole line. On this section the three wires of each line form an equilateral triangle with the points 36 inches apart; two cross arms are used, the upper one carrying four wires and the lower one two wires. At no place on the whole line are the wires transposed and no trouble has so far been experienced from induction. The substations at Watertown, Waukesha and Waukesha Beach are supplied with current by taps taken off the main line, those at East Troy and Burlington by branch lines running south from West Allis.

The new transformer building at the West Allis substation is an addition to the main building, and forms an integral part of it; it is 30x60 feet. The main floor is spanned by an electric traveling crane.

The 38,100-volt wires are carried from the pole line to strain insulators on a

structural-steel platform on top of the transformer house, whence they are brought down through the roof to the second floor by means of roof entrance bushings. Suitable choke coils are inserted in the line before the wires reach the main disconnecting switches.

The engineers of the company have devised a very satisfactory method of carrying interior wiring such as this by means of a supporting framework of piping. This gives a light structure which is easy to handle and easily put together. The crane prevents the bringing of wires through the floor of the second story to the transformers below, so they are carried from the switches on the second floor through wall insulators or bushings to strain insulators held by a steel framework fastened to the outside wall of the building. From here they are carried in through other wall insulators on the first floor to the transformers. A light pipe framework spans the transformers and supports the wiring, as shown in Fig. 1.

Six transformers are arranged along the west wall on the first floor in two banks, with the three transformers of each connected to one of the two three-phase lines. The transformers, which are of Allis-Chalmers manufacture, are of the oil-filled water-cooled type, each capable of 2000 kilowatts continuous duty. These transformers, as may be gathered from both illustrations, are of goodly size and some figures in regard to them may be of interest. Each transformer is 148 inches high and 85 inches in diameter. Over 2000 gallons of oil are required to fill each one and its weight when filled is approximately 55,000 pounds. Two independent sets of cooling coils are installed, so that if the passage of water is stopped in one the other can take care of the cooling. The transformers are of the shell type, as disclosed by Fig. 2, which shows the interior structure of one of them with the core sheets partly assembled around the coils.

The 13,200-volt wires from the transformers are carried through bituminized fiber ducts in the floor of the room to the opposite side where they are connected to oil switches. From these switches the lines go down to the distribution busbars in the basement. Feeder wires are carried from the busbars back to other oil switches controlling the feeder lines and thence up through ducts in the wall of the building to the second floor, where are located the feeder choke coils and lightning arresters; here the feeders leave the building by wires carried through wall outlets of the window type.

All high-tension switches are of the remote-control electrically operated type and are controlled from a low-tension switchboard located on the main floor of the building.

As will have been noted from the description, all 66,000-volt lines are kept on the west side of the transformer building and the 13,200-volt lines on the east side. This arrangement keeps them separated at all times and facilitates handling them as well as prevents accidental contacts between the two lines.

Four feeder lines carry the 13,200-volt three-phase currents from West Allis to the Oneida and Commerce street stations; two are made up of No. 0 copper wire and the other two (new lines just put in service) are of 340,000 circular mils stranded aluminum wires, equivalent to No. 0000 copper. The wires are carried part way in on poles, each line having the wires in the shape of an equilateral triangle with the points 24 inches apart, and the rest of the way (a distance of a trifle over four miles for the old line and 3.4 miles for the new line) the wires are carried in conduit.

The construction work was done under the supervision of O. M. Rau, chief electrical engineer for the company, and F. A. Vaughn, his assistant.

The Three-Wire Generator

By R. H. Williams

The three-wire system of distribution has long been a favorite one on account of the saving in the cost of copper over the two-wire system. In office buildings, machine shops, stores, manufacturing establishments and all large institutions it offers the simplest and most satisfactory means of supplying both lamps and motors economically from the same circuit.

Before the advent of the three-wire generator, two methods were employed for furnishing current to three-wire systems. One of these, illustrated diagrammatically by Fig. 1, comprised the use of two generators, *a* and *b*, each of a voltage equal to one-half the maximum line voltage, and the other (Fig. 2) provided a single main generator *G* and a balancing set *B*. Both of these methods of operating the three-wire system have been explained in detail in previous articles.*

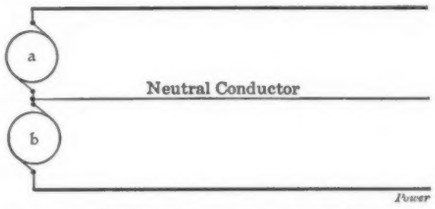


Fig. 1. Three-wire System with Two Dynamos

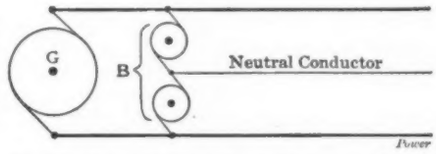


Fig. 2. Three-wire System with Motor Balancer

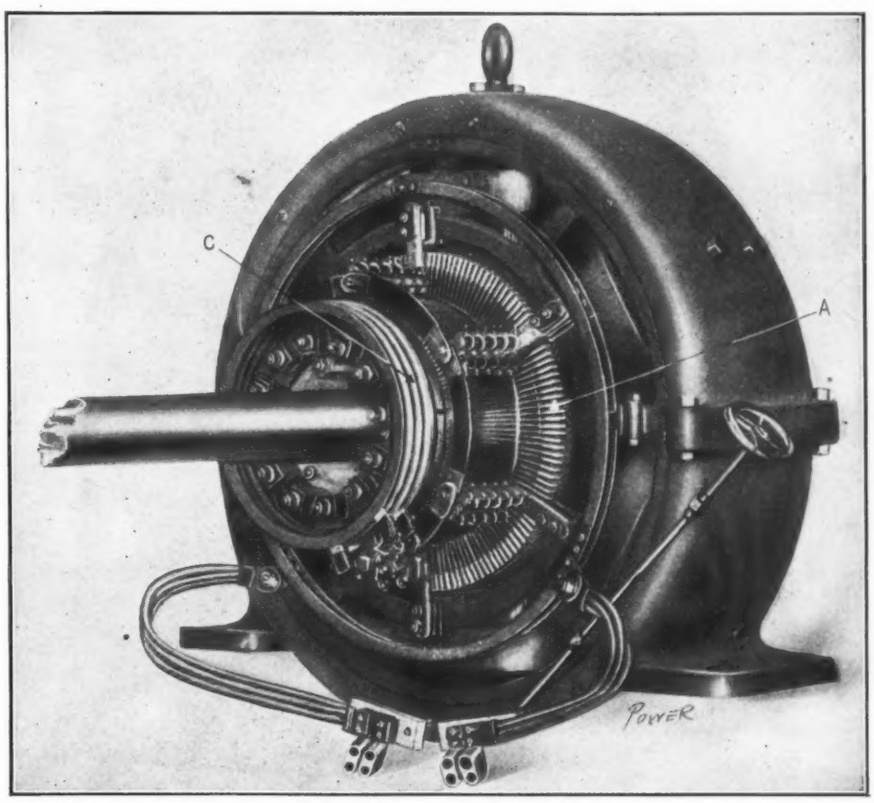


Fig. 3. Westinghouse Three-wire Generator

*Page 472, September 22, 1908, and page 52, January 5, 1909.

To serve in place of the two generators in Fig. 1 or of the generator and balancer set in Fig. 2, a single machine was devised several years ago, known as the

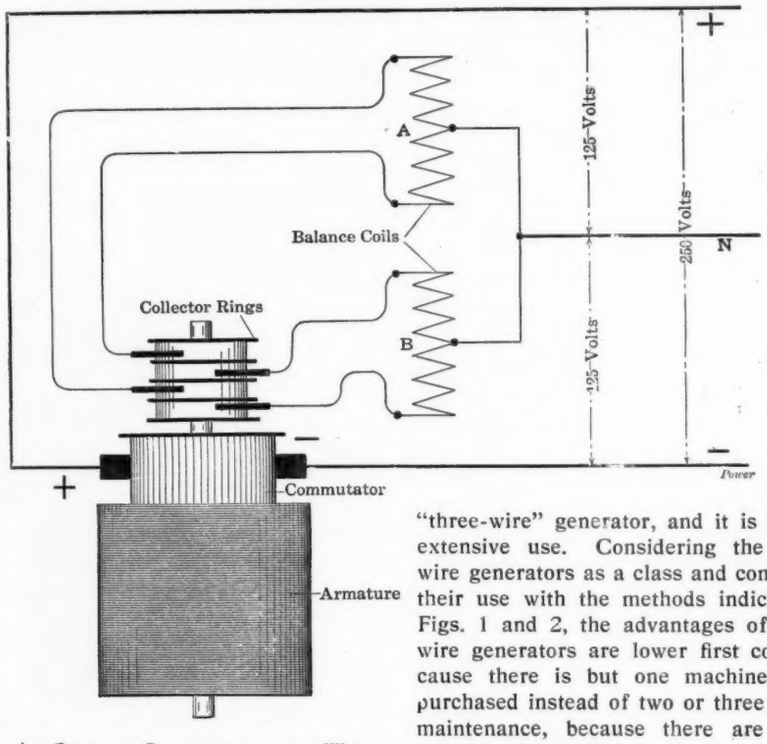


FIG. 4. CIRCUIT CONNECTIONS OF WESTINGHOUSE MACHINE

"three-wire" generator, and it is now in extensive use. Considering the three-wire generators as a class and comparing their use with the methods indicated in Figs. 1 and 2, the advantages of three-wire generators are lower first cost, because there is but one machine to be purchased instead of two or three; lower maintenance, because there are fewer parts to be cared for; higher efficiency, because one machine has smaller losses than any greater number of equal total output; less floor space required, because a single machine is used instead of two or more. The last-mentioned advantage is by no means of minor importance in cases where the machines are used in large cities where real estate is dear. With a properly designed three-wire generator, unbalanced loads are carried with no excessive heating or sparking, and the inherent regulation is such that the service is practically unimpaired by sudden or large changes in the unbalanced load.

Fig. 3 shows a Westinghouse machine of this type. The connections from the

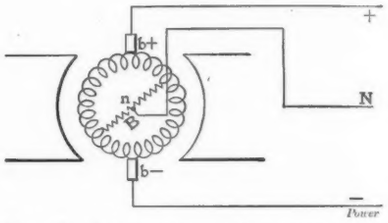


FIG. 5. ILLUSTRATING PRINCIPLE OF BALANCING COIL

armature *A* to the collector rings *C* may be exactly like those of single-phase, two-phase, or three-phase rotary converter, but the two-phase connection is used in the Westinghouse machine. Fig. 4 is the diagram of connections. Two auto-transformers or balancing reactance coils, *A*, *B*, are connected across the two-phase collector rings. These balancing coils consist each of a single winding upon a laminated iron core exactly like that of a simple transformer, and the coils are placed in iron cases filled with oil, similar to the usual practice as to small transformers. The middle points of the two balancing coils are connected to each other and also to the neutral lead of the three-wire system, as indicated in the diagram.

Fig. 5 is a diagrammatical representation of the armature winding of a bipolar generator connected to one balancing coil, which illustration is used for the sake of simplicity. From this diagram it is obvious that the pressure between the neutral wire and each commutator brush is one-half of the total armature voltage. This method of diagrammatical illustration can also be applied to multipolar generators and any required number of balancing coils.

The direct-current brushes of the generator are represented at *b*+ and *b*—. The balancing coil is permanently connected to opposite points in the armature winding. The neutral wire connects at the point *n*, the middle point of the balancing coil. The winding and connections being symmetrical, it is evident that when the "tap" points, to which the balancing coil is connected, are directly under the brushes, the balancing coil is subjected to the full voltage of the

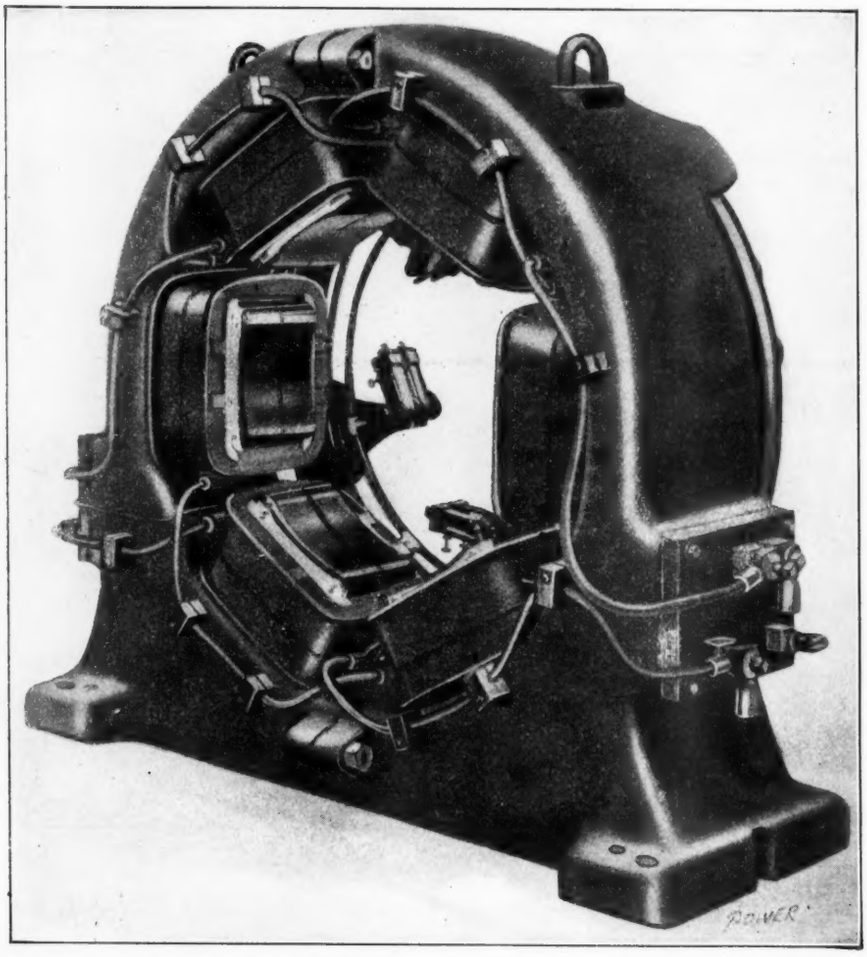


FIG. 6. FIELD MAGNET OF WESTERN ELECTRIC MACHINE

armature and the voltage between the midpoint n and the brush $b+$ is equal to that between n and $b-$, and one-half the total armature voltage. When the armature has rotated 90 degrees, so that the tap points lie directly under the centers of the magnet poles, the balancing coil is subjected to no difference of potential and the voltage between the middle point n and each brush is again one-half the total voltage of the armature, ignoring the drop in the winding of the balancing coil, which is so small that it is not important.

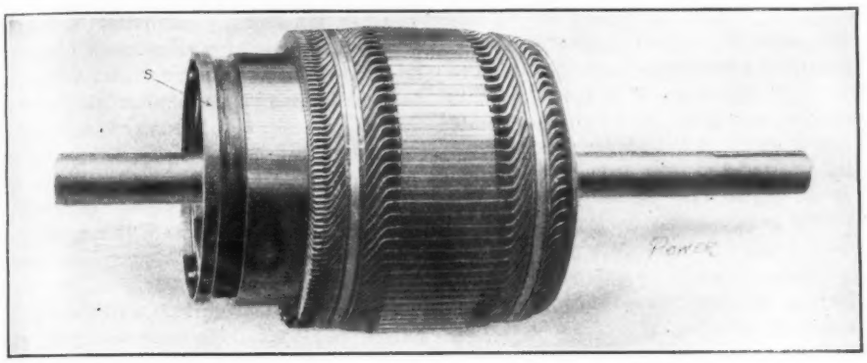


FIG. 7. ARMATURE OF WESTERN ELECTRIC MACHINE

In all other positions of the armature, the voltage between the point n and the brush $b+$ is the resultant of half the voltage of the balancing coil and that of that part of the armature winding between one tap point and the brush. Correspondingly, the voltage between n and $b-$ is the resultant of one-half the voltage of the balancing coil and that of that part of the armature winding between the other tap point and the brush $b-$. These two are always equal, so that the voltage between n and one brush is always equal to that between n and the other brush, and n is therefore the neutral point and may be so used. The only influence that prevents this arrangement from giving a perfect division of the total voltage between the two branches of the system is the resistance of the windings and circuit connections, and this is so small relatively, that it does not cause serious discrepancy under ordinary operating conditions.

The object in using two balancing coils, as in Fig. 4, instead of one, is to reduce the fluctuations, during each armature cycle, of the resistance and reactance effects of the coils. When the tap points are directly under the brushes these effects are maximum, and when the tap points are midway between brushes the effects are minimum. Therefore, when two coils are connected at right angles to each other (in the elementary bipolar case), each one tends to neutralize the disturbing effects of the other one.

The Western Electric Company's three-wire generator is shown in Figs. 6 and 7. This machine differs from the Westinghouse machine in mechanical details and in the use of a balancing winding on the armature core, with its neutral point connected to a single slip ring, instead of four collector rings connecting the main armature winding with external balancing coils. The view of the armature, Fig. 7, shows the single slip ring alongside the commutator. The balancing winding lies beneath the main armature winding, at the bottom of the slots, and it is connected between the main winding and the slip ring so that the slip ring always has a potential midway between the potential difference of the commutator brushes when the machine is in operation. Large conductors are used for the auxiliary winding to avoid objectionable resistance effects with large unbalanced loads.

Three-wire generators may be operated in parallel, just like ordinary machines, irrespective of the number of poles and speed of each, and are regulated for equal voltage in the same manner. Two-wire and three-wire generators may also be run in multiple; where there are several generator units therefore, it is practical to operate one three-wire generator, having sufficient capacity to carry the difference between the loads on the two sides of the system, the other machines being of the ordinary type. It is, however, advisable to provide duplicate three-wire units, each of sufficient capacity to provide for the maximum unbalanced condition of the system.

CORRESPONDENCE

Don't Forget the Equalizer Polarity

A friend of mine installed a compound-wound generator to operate in parallel with one which was already in service. The leads were run to the switchboard in conduit. The new one was started up and the main leads tested for polarity and then rightly connected to the switch. The equalizer wire was connected to its switch but was not tested for polarity. When all was complete the new generator was started and its switch closed; they were then in parallel. Then he closed the equalizer switch, and big fireworks and smoke were the results. After they got the plant to a standstill he began to test out and found the equalizing connections of the generators of opposite polarity. So it is best to look after that point on starting up new generators.

The simplest method I know of for testing the polarity of circuits when a polarized voltmeter is not at hand is to tear off a piece of a blueprint, wet it and hold it across the line for a few seconds. Where the negative side comes in contact with the paper it bleaches it out white.

F. W. REED.

Havre, Mont.

Trouble with an Exciter Driven by a Synchronous Motor

A 500-kilowatt synchronous motor was used both as a feeder regulator and to drive two direct-current exciters belted to it. Its operation was very unsatisfactory, as the incandescent lamps supplied from the same busbars showed a very noticeable flickering, the voltage varying continually two volts each way from the average.

The trouble seemed to be due to driving the exciter from the synchronous motor shaft, and we therefore belted it to a separate motor supplied from a different feeder. This stopped the fluctuations and gave perfect satisfaction.

R. E. BRADLEY.

Winchester, Mass.

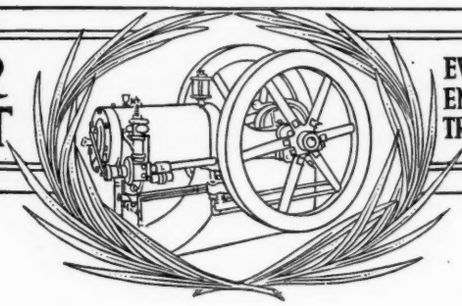
A Case of Reversed Series Connections

My friend Tom ran an engine in a chewing-gum factory and one day while paying him a visit I noticed that every time an additional motor was started in the plant the voltage would drop considerably and the rheostat would have to be adjusted to bring it back to normal, so that by the time he had a full load he had all of the resistance cut out, although the generator was a compound-wound machine. Tom said that it was not caused by belt slippage and that the machine had done that way ever since it was started, about three months before. The following Saturday afternoon I went over again and after the factory shut down I simply reversed the connections of the series field winding and we tried the machine and found that that had corrected the trouble. Tom had a joke on the local electrician who installed the machine and my wife has been chewing gum ever since.

E. H. LANE.

Kansas City, Mo.

GAS POWER DEPARTMENT



EVERY THING WORTH WHILE *in the* GAS ENGINE *and* PRODUCER INDUSTRY WILL BE TREATED HERE *for the* USE *of* PRACTICAL MEN

The Gas Engine*

By Dr. Charles E. Lucke†

It was not until the establishment of the relations between heat and work, and the conditions for transforming the former into the latter, as embodied in that body of principles of physical laws known as thermodynamics, that the great possibilities of the gas system were recognized. In the steam system of securing work from heat, the heat is added to water, turning it into high-pressure steam; the steam then acting like a compressed spring, can either give itself velocity, as in the turbine, or push on a piston, as in the reciprocating engine, but no matter how it works, much of the heat put into the steam in making it is carried away in the exhaust steam, and this quantity is very large, estimated at about 60 per cent., even when working with a good vacuum, and considerably more when the exhaust steam is discharged into the atmosphere without condensing. No matter how perfect the steam-engine mechanism, these conditions, together with some others, impose a low limit on the efficiency of utilization.

No matter what the system of changing heat into work, there will be limits to the possible performance of even a perfect mechanism, but the limit is different for different systems. The gas system has a much higher possible efficiency limit than the steam system, and one of the greatest contributions of thermodynamics is the determination of this fact and the establishment of a method of calculating the limit of efficiency, or the maximum possible amount of heat that may be transformed into work by applying the heat of the fuel to gases instead of to steam, using the spring-like action of gases to do work on pistons, much the same as does steam in piston engines.

Expansion of Heated Gases

A mass of any gas or combination of gases, or the gaseous products of combustion, will, if confined in a chamber and there heated, show a rise in pressure, and this increased pressure may be used to push a piston, the gases expanding as the piston moves and continuing the push as long as permitted. Similarly, if the heating be continued as the piston advances, the pressure may be maintained higher and the push augmented. Early attempts to embody such gas-heating and expanding processes in a mechanism to constitute an engine, based on the heating of air inclosed in cylinders by a fire outside, amounted to very little because only a small portion of the heat of the fire actually reached the inclosed air, and of this small amount only a fraction was converted into work. A still more serious difficulty, however, was encountered in the rate of working, as air can be heated only very slowly through plates, so that the engine had to be enormously big to give a little power and therefore prohibitively expensive.

After many failures two basic principles were finally recognized: first, that some faster method of heating was necessary; and second, that air or a gas, previously compressed by a piston before heating, is capable of yielding more work for the heat it receives than without compression. The deduction from the second principle is that by compressing higher and higher before heating, the efficiency of utilization of the heat may be extremely high, approaching even 80 per cent.; and this may be realized if no mechanical difficulties are encountered in carrying out the process.

The rapid method of heating needed is to be found in the process of combustion itself, for there is no more rapid method of making cold gases hot than by choosing such gases as will combine chemically and burn, heating themselves in the process of combustion. Early attempts were made to use coal fires; air pumped through a fire inclosed in strong, tight chambers became very hot almost instantaneously, and the problem seemed to be solved. However, the difficulty of regulating the fire, feeding coal and removing ash when the furnace was bolted inside of a thick metal vessel, combined with the cutting action of the ash dust on the cylinder walls, soon showed that the mechanical handicaps of this process were too serious. Attention was then turned to an older combustion process, which for some inscrutable reason, perhaps an unfounded fear of destruction, had not received much attention: the process of explosive combustion.

Fuels and Combustion

All fuel, whether solid, liquid or gaseous, consists of only a few primary combustible substances or chemical elements, which when combined in various ways give to natural fuels their special form. The two important combustible elements are: first, the solid black carbon familiar in a variety of forms; and second, gaseous hydrogen, the lightest gas known. Several hundred carbon and hydrogen compounds are known, some existing as gases, some as liquids and others as solids, but all useful as fuel—fuel in the sense that when heated in the presence of oxygen gas they will combine chemically, giving out heat very rapidly and turning into other gases: carbonic acid gas or carbon dioxide, and water vapor. In the formation of carbon dioxide one particle of solid carbon unites with two particles of gaseous oxygen, making one particle of gaseous carbon dioxide, and in the formation of water vapor two particles of gaseous hydrogen combining with one particle of gaseous oxygen make one particle of very hot water vapor—in fact, superheated steam which, when cooled, may become liquid water.

If hydrogen be mixed before igniting in just the right proportion with oxygen so that after combustion no hydrogen remains unburnt and no oxygen left unused, then combustion will take place in that peculiar way described as explosive. This explosive property is possessed by a substance when after lighting it at one spot the flame will itself travel quickly through the whole mass. A room filled with such a mixture and ignited at the center would exhibit a beautiful phenomenon if it could be observed without danger; the flame would start from the central or starting point and move with equal speed in all directions so that there would be formed a true ball of fire rapidly increasing in size until all the mixture had been burned. Of course, this rapid heating would raise the pressure, blowing out windows and possibly also the walls, as they are not constructed to resist such pressure; but if carried out in strong iron chambers the only effect would be a mass of high-pressure hot gas formed in almost the wink of an eyelid. This explosive property is peculiar to any sort of intimate mixture of fuel and oxygen; and as air is one-fifth oxygen, also to any intimate mixture of fuel and air, be the fuel in the form of fine coal, charcoal dust or even flour dust, fine liquid-fuel spray such as an atomizer may produce or as a combustible gas, such as is used for lighting, produced in any convenient way, or the vapor of a liquid fuel such as

*Abstract of the fifth Hewitt lecture, delivered on March 7 at Cooper Union.

†Professor of mechanical engineering at Columbia University.

might be obtained by heating gasolene. It is such explosive mixtures as these that are now used in gas engines to produce the rapid heating of confined gases, and these gases are always compressed in cylinders by pistons before ignition.

ELEMENTS OF THE MODERN ENGINE

The modern gas engine, no matter whether its fuel supply be primarily gas, oil or coal, will involve apparatus the principal function of which is to create from the fuel as it exists an appropriate explosive mixture for use in the cylinders. An explosive mixture, such as the gas engine uses, consists of air mixed with gaseous fuel or with the vapor or mist of liquid fuel in certain proportions, with which active mixtures there will be certain neutral substances like carbonic acid or water vapor. The first essential process in the operation of a gas engine is, then, the making of a mixture of appropriate sort, and this process in turn involves many secondary processes, some of which will be traced. When the mixture is made it must be introduced into a cylinder and there treated or subjected to certain processes, the first of which is compression. By the movement of a piston the mixture is forced into a small space, causing the pressure to rise, and at some high pressure thus developed by the piston alone, the fuel intimately mixed with all the air it needs for its combustion and no more, will be ignited either by hot metal or an electric spark. The result of the ignition of this highly compressed and confined explosive charge will be not a noise, not a disruption, nothing more complicated than a rapid heating of the entire mass as the flame passes through it, accompanied by a rise of pressure. That the flame will pass through the whole mass of confined mixtures is the prime characteristic of explosive mixtures, whether they be of this gas-engine sort or of the gun-powder sort. Gun powder is a mixture of fuel and the oxygen it needs to burn it, all in the solid form. There is rapid-burning powder and slow-burning powder, and we have learned how to apply powder of varying rates of combustion to projectiles of different weights, sizes and shapes to secure the most effective driving of the projectile by giving it the highest muzzle velocity with the least tendency to smash the gun or to dissipate energy. Compared with most gunpowder, explosive gaseous mixtures such as are used in engines are very slow-burning, and the rate at which they burn or the rate at which the flame travels through them from particle to particle is technically called the rate of propagation. As a consequence of this rapid heating of the confined gases the pressure rises to perhaps two or three times what it was before, occasionally four and one-half times, and the explosive combustion has performed its useful function. This high gas pressure acts on the same piston that originally compressed the charge into the confined space commonly called the cylinder clearance or combustion chamber, or breech end.

On the return stroke the high-pressure gases drive the piston back, and do very much more work than the piston itself did on the cold gases in compression; the difference is the useful work. The burnt gases, when the piston has reached the end of the stroke, must be expelled and the whole series of operations of making the mixture, introducing it, compressing, exploding, expanding and expelling it, is carried out automatically by means of mechanism designed with this end in view. The gas engine is then primarily a cylinder with a piston and certain means for making proper mixtures, getting them into the cylinder, treating them properly after they arrive, getting the burnt gases out, and doing it as often as may be necessary, as rapidly or as slowly as may be required, and using as much mixture as may be needed to do the required work.

[The remainder of the lecture consisted of an elementary explanation of the features of construction and operation of the modern gas engine. These have been described in our columns several times and are therefore omitted here.]

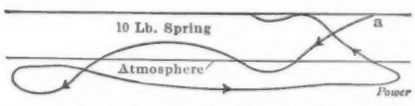
Setting Gas Engine Valves

BY JOHN S. LEESE

I followed the recent discussion of this subject with interest. In the March 2 issue, Mr. Tilden said: "The importance of setting out with a cylinderful of mixture is hardly open to discussion and the only way to secure that result is to open and close the valves exactly on the dead-center points." Let us consider an engine with this valve setting. At the end of the expansion stroke the pressure will be between 25 and 40 pounds above atmosphere. At the out-center the exhaust valve *begins* to open. The combined influence of the consequent wire drawing and the slowly moving piston will not allow this pressure to fall instantly, as Mr. Tilden seems to think. By the time the valve is fully opened, which will be about 40 degrees on the in-stroke, the piston will be moving rapidly, and, as the exit of the cylinderful of high-pressure gas has been checked by the partial opening of the port, the piston will be working against an additional back pressure in forcing out the gas when the full opening is obtained.

Toward the in-center position, as the piston slows down, the exhaust valve *begins* to close, and the result of the wire drawing combined with decreased piston speed will be that the clearance space will be filled with burnt gases at a pressure appreciably above atmospheric.

The inlet valve opens at this instant and the piston slowly reverses. Before any fresh mixture can enter the cylinder the pressure behind the piston must be below atmospheric. Under the given conditions of valve setting, with the consequent pressure in the cylinder at this point, it will be some time before the gas and air forming the fresh charge will be



MR. LEESE'S STOP DIAGRAM

set in motion through the restricted valve opening, so that when the piston accelerates, it will draw rapidly away from the incoming charge. When the piston gets toward the out-center position the inlet valve is closing and wire drawing the new charge, which is therefore prevented from catching up with the piston, as it tends to do by virtue of its inertia. At dead center the valve is shut.

Have we got a cylinderful of mixture? No. In the first place the pressure is below atmospheric, and in the second place there has been no scavenging whatever and the foul exhaust gases entrapped in the clearance upon exhaust closure are still present, *and their volume is greater by an amount corresponding to the difference between the final pressure at the end of the in-stroke and the final pressure at the end of the out-stroke.*

It would be futile to give one set of valve openings and closings for all cases because those for each case must depend upon the cam design, the valve and port areas, the piston speed and other variable conditions. I do not think any difference would be necessary for vertical and horizontal engines were it not for the fact that vertical engines generally run faster and have smaller individual cylinders than horizontals of the same power.

With a piston speed of 580 feet per minute and generously designed ports and passages the following settings are the best for one particular case:

Inlet opens, dead center (in-center).

Inlet closes, 23 degrees late (after out-center).

Exhaust opens, 45 degrees early (before out-center).

Exhaust closes, 15 degrees late (after in-center).

In this case the main inlet valve admits air slightly before the gas valve opens, so that no fresh gas is lost along with the exhaust gases and very complete scavenging is effected. I say "slightly" advisedly, meaning not more than five degrees, and I do not wish to be understood as saying that the exhaust and gas ports are not open simultaneously because they are, and still no gas is wasted and backfiring is almost unknown. In most modern de-

signs where separate air and gas valves are used, the tendency is to open the air valve before the gas valve cracks, for the reason given.

In his last letter Mr. Tilden ridiculed the 65-foot exhaust pipe, and Mr. Buschman, in reply, unfortunately did not give a diagram. I supply the deficiency herewith. In this case the exhaust valve opened 40 degrees early and closed about 35 degrees late. The air valve opened 40 degrees early and the gas valve opened just as the exhaust nipped shut. Thus the air and exhaust valves were both open together through 75 degrees. The pressure on release was about 35 pounds. This pressure discharged into the 65-foot exhaust pipe and when the velocity of the piston approached zero, toward the in-center, the column of gas in motion along the pipe caused a partial vacuum to be formed behind the piston. At this time the air valve is opened and air is sucked through the cylinder and out through the exhaust port by the receding column of exhaust gases. Thus by the time the gas valve is due to open there is an abnormally good vacuum in the cylinder and an entire absence of foul gases.

Following the diagram with the arrows, starting from *a*, the effect of the first release is shown by the consequent great pressure difference; it is to impart motion to the 65-foot column of gas and air in the exhaust pipe and the effect of the inertia of the column is shown by the first dip below the atmospheric line on the diagram. Now the piston is moving at its highest speed and the pressure rises, as shown, as the piston catches up and pushes forward the column of gas. The consequent acceleration imparted to the column of gas causes it to draw away from the piston as the latter slows down toward in-center, causing a vacuum of about three pounds about the time the air valve opens. It will be seen that throughout the suction stroke the pressure remains nearly constant.

Thus is a "cylinderful" of mixture secured, as nearly as may be, and it is, in addition, *pure* mixture. The main inlet valve closes after the piston has started on its compression stroke so that the inertia of the induced charge shall not be wasted. It is impracticable to secure an actual cylinderful of mixture at atmospheric pressure, under normal conditions of running, unless the mixture is supplied under pressure.

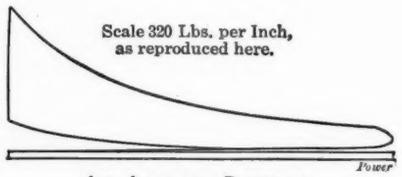
According to the *Mechanical World* four parts alabaster plaster and one part of finely pulverized gum arabic mixed with a cold-saturated borax solution into a thick paste, make an unequaled all-round cement for stone, glass, bone, horn, porcelain and wood, which becomes hard as marble and possesses the agreeable quality of not solidifying immediately, but in 24 to 30 hours.

Test of a Single Acting Gasolene Engine

By John P. Kottcamp

A series of tests were made recently by the writer and S. D. Fowler, formerly assistant professor of heat engineering at the Pennsylvania State College, for the purpose of studying the heat distribution in a gasolene engine. The tests were made on a 5-horsepower Otto engine of the familiar single-acting horizontal type equipped with a long trunk piston. The cylinder was 3⅛ inches diameter of bore and the stroke was 5 inches. Ignition was effected by means of a make-and-break electric igniter, operated mechanically from the cam shaft.

In these tests special care was taken to determine accurately the distribution



An Average Diagram

of the heat energy. The air for the engine was furnished by a Westinghouse air-brake pump which forced the air through a large meter, where it was measured, into a rubber aspirating bag from which the engine obtained the necessary supply. The pressure in the bag was maintained as near atmospheric as possible. The gasolene was supplied from a large can mounted on scales located somewhat above the level of the engine. The current for ignition was obtained from a lighting circuit, a few lamps being connected in series with the ignition circuit. The explosions and revolutions were recorded by a chronograph. The jacket water was carefully weighed in tanks and the inlet and outlet temperatures were taken every five minutes. Before starting the test the engine was allowed to warm up and get into normal working condition. The power generated was absorbed by an ordinary prony brake. Cards were taken with a Thompson indicator, using the pendulum type of reducing motion. All apparatus used was carefully calibrated.

For recording the revolutions per minute a chronograph was used.

Following are the results of one of the tests:—

Duration of trial, hr.	1
Brake load, net, lb.	16
Length of brake arm, in.	48¼
Gasolene per hour, lb.	4.062
Air per hour, cu.ft.	731
Jacket water per hour, lb.	363
Jacket water temperature entering, deg. F.	50.9
Jacket water temperature leaving, deg. F.	130.46
Jacket water temperature rise, deg. F.	79.56
R.p.m. (average from chronograph)	332
Possible cycles per minute	166
Explosions per minute (average from chronograph)	137
Ratio of explosions to possible cycles	0.824
Temperature of exhaust gases, deg. F.	433.4
Temperature of room, deg. F.	64
Gasolene vapor weight per cubic foot, lb.	0.2313
Air weight per cubic foot, lb.	0.0733
Mixture weight per cubic foot, lb.	0.0770
Specific heat of air (constant volume)	0.169
Specific heat of exhaust gases (constant pressure)	0.2375
B.t.u. per cubic foot gasolene vapor	3783
M.e.p. of power stroke, lb.	94.6
M.e.p. compression stroke, lb.	15.25
M.e.p. net, lb.	79.35
Indicated horsepower	4.728
Brake horsepower	4.195
Mechanical efficiency, per cent.	88.66
Gasolene per i.h.p. per hour, lb.	0.8585
Gasolene per b.h.p. per hour, lb.	0.9686

HEAT PER HOUR.

	B.t.u.	Per Cent.
Heat supplied	66,414	100
Heat absorbed by jacket water	28,880	43.49
Heat exhausted	5,058	7.62
Heat equivalent of indicated work	12,034	18.12
Heat radiated and unaccounted for	20,442	30.77
Heat per i.h.p. per hour	14,036	

EFFICIENCIES.

	Per Cent.
Possible thermal	38.20
Thermal from i.h.p.	18.12
Thermal from b.h.p.	16.07
Ratio of actual to possible thermal	47.46

Method of Obtaining Results

Following is the manner in which the more important items were figured.

One pound of gasolene vapor at 32 degrees Fahrenheit and 14.7 pounds pressure occupies 4.06 cubic feet. At the temperature of the room (64 degrees Fahrenheit) and atmospheric pressure one pound occupies

$$4.06 \times \frac{64 + 460}{492} \times \frac{14.7}{14.7} = 4.32$$

cubic feet. Therefore one cubic foot of vapor weighs $\frac{1}{4.32} = 0.2313$ pound.

By similar calculation one cubic foot of air is found to weigh 0.0770 pound.

The specific heat of the exhaust gases was figured by the well known Grashof formula:

$$C_p = \frac{(0.2375 \times R) + 0.343}{R + 0.48}$$

in which R = ratio of air to gasolene vapor by volume.

Fig. 1 shows a typical indicator diagram from this test, the dotted line representing the expansion line as given by the indicator. The average value of the exponent of the expansion curve was 1.3 and that for the compression curve was 1.35; using these exponents, the following pressure and temperatures were figured from the diagram and the relations between pressure, temperature and volume in adiabatic expansion:

Point.	Pressure. Lb. per Sq.in.	Temperature. Fahrenheit Thermometer.
Intake	14.3	64
Compression	68.25	327.6
Explosion	264	2586
Release	52	1637

The gasolene used during these tests was of the kind commonly used in gasolene engines. Its heat value was determined by burning a sample in the Junker calorimeter. From this test the heat value was found to be 16,350 B.t.u. per pound.

FROM READERS *with* SOMETHING TO SAY

PRACTICAL INFORMATION *from the* MAN *on the* JOB: A LETTER GOOD ENOUGH *to* PRINT *is* GOOD ENOUGH *to* PAY *for*

Enigmas

The following enigmas are in line with several others that have lately cropped up in the correspondence columns of POWER. Unlike others, however, I attempt to solve the seeming paradoxes. A 10x18-inch, slide-valve engine was overloaded to the extent that five pounds drop in the boiler pressure would cause a perceptible and aggravating diminution of speed.

It was small wonder then that the engineer, when advised by the manager of the installation of a cloth-heating machine, which would require three horsepower extra of the little engine, at first strongly objected. A few days later, however, the manager was surprised and puzzled when informed by the engineer that he "guessed three horsepower, more or less, would not make much difference one way or another," and the engineer actually became anxious that the machine, which was to use exhaust steam, and consisted mainly of three 7-foot copper drums, be installed. One proviso only he made, that no valve be placed between the drums and the atmosphere. When the machine was started, those who had collected round the engine, expecting to see it come to a stop, were surprised to note that it actually ran smoother and better.

The solution is simple. The engineer had figured out that, owing to a tortuous exhaust pipe, and the comparatively large volume of steam used, the average

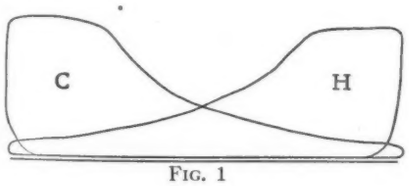


FIG. 1

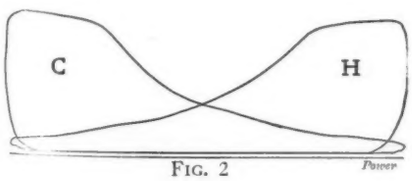


FIG. 2

BEFORE AND AFTER CHANGING FLYWHEEL

back pressure on the engine must be about 5 pounds. When the exhaust was turned into the drums of the machine it found ample space in which to expand, and a straight, free outlet, with the result that the back pressure was easily reduced 4 pounds. His arithmetic was as follows:

$$\frac{P \quad L \quad A \quad 2N}{\frac{4 \times 1.5 \times 78.54 \times 300}{33{,}000}} = 4.3 \text{ H.P.}$$

Horsepower required = 3

Gain = 4.3 — 3 = 1.3 *horsepower.*

At a certain mill, a 20-foot flywheel was substituted for a defective, 12-foot wheel. It was expected that, as the new wheel weighed eight tons more than the old one, better regulation would be obtained, but no one anticipated the result that, apparently, 10 horsepower would be lost in driving the same machinery. The engineer will show you diagrams, Figs. 1 and 2, and give you data from which you are enabled to form the following formulas:

1. Before the change

$$\frac{P \quad L \quad A \quad 2N}{\frac{46.8 \times 3 \times 314 \times 200}{33{,}000}} = 267 + \text{H.P.}$$

2. After the change

$$\frac{45 \times 3 \times 314 \times 200}{33{,}000} = 257 \text{ H.P.}$$

Difference = 10 *horsepower.*

But if you ask him how many lumps of coal he saves, he will tell you that his microscope is not powerful enough to magnify the lumps so that he can count them, and will add that his hair is being turned gray by pondering over the problem.

Yet it seems to me the solution is very simple. The whole difference lies in the fact that the number of revolutions was assumed to be the same in both cases. It is obvious that the mean effective pressure is higher in one case than in the other, from which it is inferred that the cutoff is later in one than in the other. It must follow, then, that the engine in the first case could not have been running as fast as in the second.

One engine, it is true, may use *more steam per horsepower-hour* than another; but if two engines of like proportions are given, then if the products of $L \times A \times N$ are identical in both, P in each cylinder must also be identical to produce the same horsepower. If P varies, then N will also vary. The above example furnishes food for thought to those who take the working hight of the governor as the criterion upon which to base the economical operation of the engine with a certain setting of the valves or a certain receiver pressure. Who can positively say without actually weighing the steam whether the engine used more or less steam after the change of flywheels? The practical engineer will tell you that the engine uses less steam with the heavier flywheel, and will point to the higher working plane of the governor

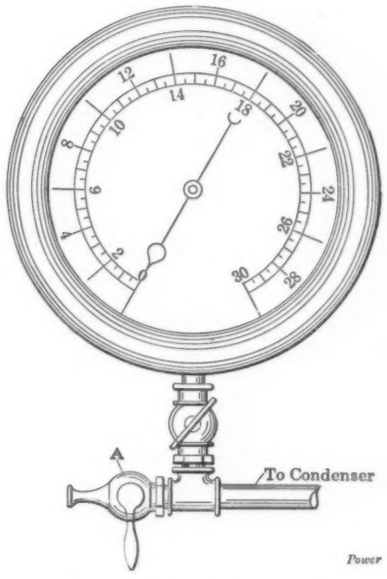


FIG. 3. PIPING TO GAGE

to support his contention. The theorist will tell you that as the governor has assumed a higher plane, the engine must be going faster, and therefore steam fills the cylinder oftener and the clearance losses are multiplied; the flywheel being heavier the friction of the engine is increased, and the diagrams show that there is more drop to the steam line. Last, and by no means least, the fireman will tell you that "It does not make a bit of difference." If calculating the speed from the shaft of the machinery back to the engine is allowable, the fireman is quite right, for this gives the engine a speed of 96 revolutions per minute with the old flywheel, and reduces the calculated horsepower to 256.5.

Two other out-of-the-ordinary observations are here briefly narrated. A new cross-compound engine was installed in a lighting plant. The engineer was greatly puzzled over the action of the receiver pressure, which dropped instead of climbing up with increased load. With a light load the gage read 10 pounds, with a heavy load it read 7.5 pounds. The cause was found to be a mistake in design, which caused an excessive travel of

the low-pressure, cutoff cam for slight changes in governor plane.

I once worked in a plant which operated condensing. The best vacuum that I could obtain, while running the air pump at a certain number of strokes per minute, was 25 inches. I would not have given this much consideration if it were not for the fact that two minutes after my mate relieved me, that vacuum gage would register 27 inches, while the pump ran at exactly the same number of strokes. The gage was piped as shown in Fig. 3. Close examination failed to reveal any secret push-buttons. To determine whether the finger was binding, I quickly opened and shut the pet cock *A*, and found when the pointer came to a rest, that I had apparently gained a half inch of vacuum. A second trial gave me another half inch. The third time I kept the pet cock open for about 15 or 20 seconds, and found after closing it, that I had fully 27 inches of vacuum. Moreover, the pointer stayed there throughout my watch. I have since tried this in other plants, where the vacuum gages were piped with a pet cock as shown, and I have invariably gained from 1 to 2 inches of vacuum. Tests with the indicator, however, proved conclusively that the gage, though correct under a test, did not correctly register the vacuum in the condenser, before the pet cock was opened. The theory advanced concerning this is, that as the gage is usually placed at the highest point in the condensing system, some air or vapor collects in the tube, and as a result, when the pet cock is opened, the inrushing draft siphons this air out, or condenses the vapor present, or cools the tube and a better vacuum is registered.

H. HUGHES.

Roxbury, Mass.

Repairs to a Corliss Engine

A few years ago I was in charge of a large electric-light and power station containing several Corliss engines, all of which had passed through many years of hard work, hard usage, and excessive overload.

One of these engines was a tandem-compound, 20 and 36 by 48 inches, and was originally installed to develop about 350 horsepower at 70 revolutions per minute and a boiler pressure of 90 pounds. At the time I came to the station, the speed of this engine had been increased from 70 to 90, and the steam pressure, through the installation of new water-tube boilers, had been raised to 200 pounds. Under these conditions, when the engine was fully loaded, the governor was pretty well down on the column, and cutoff occurred at about three-eighths stroke. Both cylinders of this engine were jacketed.

A few months before I took charge of the plant, the engine had been nearly wrecked by a charge of water in the high-pressure cylinder resulting in a bad crack. The cylinder had split through the strengthening webs of both tie-rod lugs, as shown at *A* in Fig. 1, and at the same time, the foundation between the high- and low-pressure cylinders had been carried away.

Everything was overloaded and no time could be spared for repairs to engines or dynamos. New engines were being installed, and as these would soon be ready, the subject of repairs to the tandem engine was taken up. At first, I thought that a new high-pressure cylinder would be about all that was needed, but after a careful survey of the foundation I decided that it would be useless to install a new cylinder without renewing a large part of the foundation as well.

It was found that the repair would require six weeks, which was a far longer time than the engine could be spared just at this time, and also, that the price of the cylinder together with the foundation work would be prohibitive.

Another plan had to be adopted. I decided to dispense with the tie rods altogether, and substitute for them the split trunk shown in Fig. 2. By removing all the studs in the back head of the high-pressure and the front head of the low-pressure cylinder and replacing them with tap bolts, the trunk and the cylinder heads could be readily secured in place. The slot *D* in the split trunk would afford ample room for repacking the piston-rod stuffing boxes, by working from both sides of the engine at the same time, and the low-pressure cylinder and piston could readily be examined by twisting off the top half of the trunk, dropping the lower half, and removing the low-pressure cylinder head in the usual manner.

While waiting for the split trunk and tap bolts to be made, the foundation was tackled. One end of a 20-inch I-beam was let into a wall over the high-pressure cylinder and the other blocked up solidly, directly over the guide post, as shown in Fig. 1. Across the top of the beam four straps of 4½x⅞-inch flat iron were placed, each drilled to take two 1⅛-inch eyebolts as shown. The lower ends of the bolts were slipped over the cylinder-head studs and secured by the nuts.

As soon as the I-beam was set, and the bolts well strained, the foundation was renewed to the point *G*, Fig. 1. When the foundation was finished up to within ⅝ inch of the cylinder bases, a line was put through the cylinders, and they were brought dead in line. Then the cylinder bases were rammed up with portland cement and fine gravel.

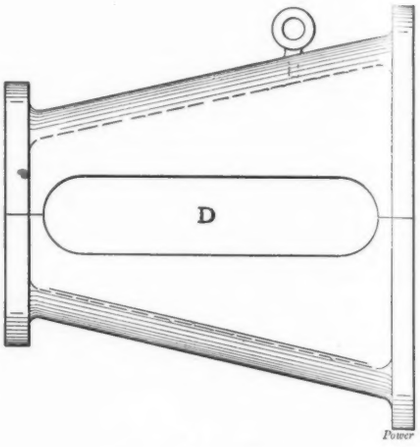


FIG. 2. SPLIT TRUNK

Next the tie-rod lugs were drilled and broken off flush, and a piece of sheet-steel lagging fitted over all, covering, of course, the places where the lugs had been.

The split trunk fitted closely, and when bolted into place, made a neat and substantial job.

After the repairs were completed, and the engine again started, the speed was increased to 102 revolutions per minute and the load was also increased.

Due to the fact that the high-pressure jacket could not be made tight, steam

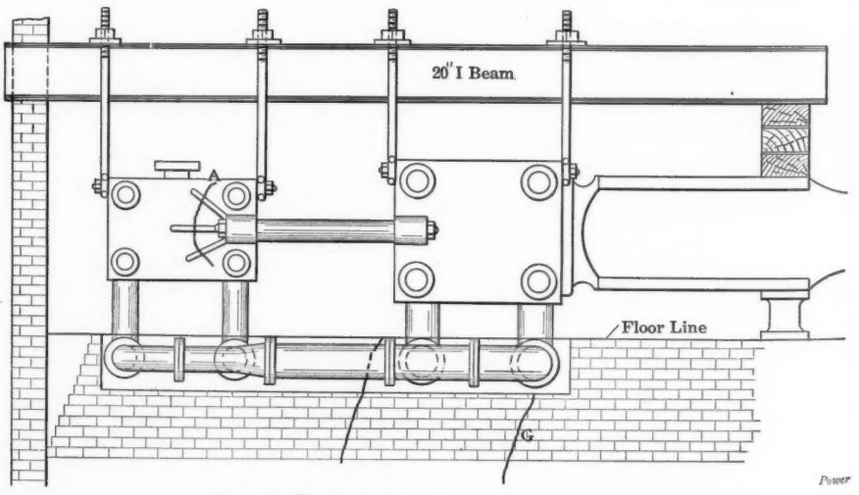


FIG. 1. TEMPORARY REPAIR ARRANGEMENTS

was left cut out of this jacket. For the six months following the repairs, the engine ran twenty-three hours out of every twenty-four, and for a great portion of each run developed over 900 horsepower.

The time required to make the repair was just eleven days.

E. A. BLACKWELL.

Kingston, N. Y.

Homemade Coal Testing Apparatus

In plants where anthracite coal is used as fuel, and where a record is kept of the amount consumed under the boilers and the quantity of ash produced, it is often desirable to know something regarding the quality of the fuel, before a supply of inferior grade has accumulated.

In the larger cities where coal is usually supplied by the dealer, in wagon-load lots, it would not be possible to secure a chemical analysis, or a calorimetric determination of each load. However, by the use of the apparatus herein described, a fairly accurate determination of the amount of incombustible matter may be made, and as the operation requires but two or three minutes, each load may be sampled before it is permitted to be dumped.

The quantity of ash usually will slightly exceed the percentage of incombustible as determined by the test.

For the smaller sizes of anthracite the following percentages of ash are the highest that should be permitted, while good coal should not contain more than one-half these amounts; No. 1 buckwheat, 20 per cent.; No. 2 buckwheat or rice, 18 per cent.; No. 3 buckwheat, barley or birdseye, 16 per cent.

The following is a list of material required for the apparatus: A one-gallon glass jar having the same diameter top and bottom; a brass or bronze cylinder made of perforated metal or wire mesh, 7 inches in diameter, closed at one end, and of the same hight as the jar perforations or mesh should be 3/32 inch; a hydrometer, a thermometer and some sulphuric acid.

Five pints of water at 60 degrees Fahrenheit are placed in the jar and sufficient sulphuric acid added so that the hydrometer will stand immersed in the liquid up to 59 to 60 on the scale. A two pound sample of the coal, secured from the top and bottom of load, is now placed in the metal cylinder and the whole placed in the acid solution. A little agitation with a stirring rod may be necessary to prevent the floating coal from buoying up pieces of rock or slate which should settle to the bottom of the cylinder. With a skimmer made of perforated metal, remove the floating coal, then remove cylinder from the jar, and after permitting it to drain slightly, weigh the incombustible matter remaining. The percentage may then be readily determined. Some pieces of almost pure coal will be sustained in the solution, at varying depths. Everything above a hight 2 inches from the bottom should be removed and considered as pure coal.

The solution may be used over and over again if the temperature is kept at 60 degrees and the density at 59 to 60 on hydrometer scale.

W. P. ANDERSON.

New York City.

Experience with Pumps

In a water and lighting plant there was a boiler-feed pump which had been in use for nearly 20 years without giving any trouble other than that arising from the usual renewal of packing and valves. Suddenly it was noticed to be working hard, and but a small amount of water was reaching the boilers. At first it was thought that perhaps the packing had become too old and hard and was binding on the plungers; this was removed and replaced by new packing, but still the trouble continued. A pressure gage attached to the air chamber indicated 190 pounds. This led to an inspection of the air chamber, which was found to be packed with sediment and the pipe leading from the pump to the valve was badly obstructed. We removed the sediment, only to find that there were two large blisters nearly touching each other on the inside of the pipe. The pipe had left the mill in this condition, and during the years it had been in use the blisters had served as pockets to catch sediment.

Shortly after this the firemen complained that they could hardly keep up water in one of the water-tube boilers. The hot-water feed line was examined for possible leaks at the joints. The blowoff valve was new. The boiler was blown off and all parts exposed to the fire were cleaned. It was then filled with hot water and held at a pressure of 165 pounds. An examination inside the combustion chamber and headers showed no leaks, so the pump was stopped and the feed valve closed. This caused the gage to lose pressure rapidly. Here was evidence of a leak but with no visible signs. Upon touching the cold-water feed line, it was found to be very hot, and further investigation revealed the fact that the disk in the check valve was missing and the globe valve in bad shape. The cold- and hot-water feed lines met on each boiler at the angle valve; on each line there was a check valve so that when the check of the cold-water line had played out, the hot water passed through and out of the bad globe valve into the cold-water line (which was closed), finding its way through an open drain into the sewer. Had this drain been closed there would have been no shortage of water in the boiler, only a possible hammering in the line.

In another instance trouble was experienced on a 2,000,000-gallon pump. Air was discovered in the service line but upon looking into several works on the line near the pumping station nothing was found. One of the operating engineers claimed that the trouble was in the packing at the water end of the pump, but the chief insisted that the valves leaked. The valves were gone over but still the churning continued. The operating engineer finally prevailed upon the chief to procure square flax packing and the trouble was at once remedied. The former packing had been made of coiled hemp, braided by hand to the required lengths and allowed to soak in hot tallow until needed. The braiding had made the surface uneven so that when put into the stuffing box and drawn down upon, in some places it was soft and in others hard and tight against the plungers. This allowed air to be sucked in.

E. N. STECH.

Sharpsburg, Penn.

Boiler Troubles

We have eight boilers arranged two in a battery. They are of the Edgemoor, tubular type, 500 horsepower each, and are fitted with Wetzell mechanical stokers.

When we first started the plant, which is a water works containing six triple-expansion, 20,000,000-gallon pumps, we could run two pumps on one boiler. After a short while we began to be bothered for steam, and it became necessary to put in another boiler, making six in all. The trouble continued and another boiler was installed, but this did not help matters.

In the rear of the boilers and directly over the flue, there was a Greene fuel economizer. By closing the main damper and opening the economizer dampers the gases and products of combustion are induced through the economizer tubes by a fan and discharged through the economizer flue into the stack.

The trouble of which I write, was caused by the stack flue becoming partly filled with water and the fan discharging soot and dirt into the water, thus making a heavy mud which the draft from the stack would not take up. After cleaning the flue the conditions were greatly improved.

H. RICHARD.

Philadelphia, Penn.

Cotton seed and cotton-seed cake have been, according to reports, very successfully used for the generation of gas to drive a 30-horsepower gas engine in Nigeria. Six hundred pounds of cake is sufficient for 9½ hours' running, it is reported.

SUBJECTS *under* DISCUSSION

COMMENT, CRITICISM, *and* DEBATE *upon various* ARTICLES, LETTERS *and* EDITORIALS *which have* APPEARED *in* PREVIOUS ISSUES

No Heat without Circulation

Mr. Chinsano, in the January 25 issue inquires for the reason why his radiator does not work.

Air is heavier than steam, and under proper conditions will settle and allow steam to ascend. However, steam and air will not pass each other in a tube of comparatively small diameter and must have separate passages if circulation is to be secured.

Years ago, before the modern cast-iron radiators came into use, radiators were

SHEET-IRON DIAPHRAGM IN PIPE

generally made with vertical tubes of 1-inch pipe, screwed into cast-iron bases. The tubes were generally joined at the top, in pairs, by means of return bends, although about thirty years ago, I used a good many radiators, including some for hot-blast heating which had tubes 5 or 6 feet high, with vertical tubes made of 1-inch pipe with the top ends closed by being welded up in a special machine. These tubes were divided into two passages by a pulverized sheet-iron diaphragm, having the edges bent so as to give a little spring to hold it in place.

The figure gives an idea of the way in which the diaphragms were made.

It was customary to attach an air valve to the tube farthest from the supply end and to extend the lower end of this tube an inch or more below the others so that it could more readily pick up the air that would lie, of course, below the steam in the radiator base.

These radiators worked as well as any other style, and I believe some of them are still in use in the Northwest.

G. A. REICHARD.

Los Angeles, Cal.

Proper Amount of Lead

In connection with Mr. Westerfield's letter under the above caption, in the January 18 issue, there is shown in Fig. 1 an engine diagram which I am at a loss to understand. What causes the exhaust lines, the compression curve and the line showing release, to coincide exactly? Why does not the end of the expansion line showing release go out to the end of the diagram? The point of cutoff is very sharply shown. Altogether this diagram does not look genuine.

Judging from letters Mr. Westerfield has written, he has had a great deal of experience with a great many types of engines. Since he has satisfactorily overcome all difficulties, I believe he is well able to explain the questions above, and I ask him kindly to do so.

HARRY W. BENTON.

Cleveland, O.

Saving by Throttling Steam

We have been hearing so much lately about superheating steam by throttling the supply and the consequent saving that it surprises me that somebody does not reason the proposition out to its logical conclusion and claim that we can save still more by running with the throttle valve closed. W. E. Crane, in the January 18 number, tells us that expanding steam in a cylinder also superheats it, of course, as he expresses it, "neglecting the small amount of heat consumed in performing work." Let us see to what this small amount of heat consumed in performing work amounts. Mr. Crane throttled the steam from 100 to 80 pounds pressure per square inch. Let us therefore take steam at 100 pounds and expand it in a cylinder to 80 pounds.

Assume the cylinder and piston to be nonconducting and the piston to have an area of one square foot. Introduce one pound of dry, saturated steam at 100 pounds absolute pressure under the piston. It will have a volume of 4.403 cubic feet. Now let it expand to 80 pounds pressure and the volume will be 5.425 cubic feet. Consequently the piston will have moved $5.425 - 4.403 = 1.022$ feet. We can assume, with an error of less than 1 per cent., that the mean pressure during this expansion was $\frac{100 + 80}{2} = 90$ pounds. Then the work performed is

$$\left(\begin{matrix}\text{Mean pressure lb.}\\ \text{per sq.in.}\end{matrix}\right) \times \left(\begin{matrix}\text{Area of}\\ \text{piston in}\\ \text{sq.in.}\end{matrix}\right) \times \left(\begin{matrix}\text{Length of}\\ \text{stroke in}\\ \text{ft.}\end{matrix}\right) = \text{number of foot-pounds,}$$

or

$$90 \times 144 \times 1.022 = 13245.12$$

foot-pounds.

The total heat of the steam at 100 pounds is, according to Peabody, 1181.9 B.t.u. and at 80 pounds 1177 B.t.u.; consequently the pound of steam has given up $1181.9 - 1177 = 49$ B.t.u. or $4.9 \times 778 = 3812.2$ foot-pounds.

We have seen that the work done was 13245.12 foot-pounds, while the work furnished by the expansion of the steam is apparently only 3812.2 foot-pounds. Where did the balance come from? Manifestly it must have been furnished by the steam and the only way it can be explained is that some small part of the steam must have condensed and given up its latent heat of vaporization to enable the rest of the steam to continue the expansion.

There are other, more accurate, but a little more complicated, ways of proving that whenever saturated steam is expanded in a nonconducting cylinder part of the steam must condense. Now an ordinary engine cylinder is made of cast iron, a very good conductor of heat, and it is constantly radiating and dissipating heat to its surroundings; consequently the loss due to cylinder condensation must be still greater than that which the expansion of the steam calls for. It certainly is impossible for steam to superheat while expanding and doing work.

Mr. Crane's comparison of the rear door of a boiler furnace and the exhaust valve of an engine is rather far fetched. Nobody claims that the opening of the exhaust valve exposes the cylinder to the temperature of the exhaust pipe. It is the expansion of the steam while in the cylinder and the resulting lowering of the temperature of both the steam and the walls of cylinder that cause all the loss due to cylinder condensation. And the only way to avoid it is to superheat the steam before it enters the cylinder to a degree high enough to overcome the tendency of the

steam to condense during the entire expansion.

The superheating of steam by throttling is a different matter entirely. In this case the heat energy due to expansion is expended upon itself and probably does cause a few degrees of superheat. But when one considers that good coal must be used under the boilers to force the pressure up to say 100 pounds merely for the sake of getting a few degrees of superheat by throttling it to 80 pounds I don't see where the economy comes in. It certainly would be greater economy to install superheaters. Another thing that seems to have been lost sight of is that the volume of a pound of steam is greater at 80 pounds than it is at 100 pounds; therefore to pass the same weight of steam the velocity must be increased in the same proportion. This increase in velocity is gained only at the expense of some of the energy of the expansion of the steam and so robs it of just that amount. The kinetic energy due to the velocity of the steam is, as far as the engine is concerned, a total loss.

A. E. MUELLER.

Mayville, Wis.

Marine Engine of the Future

Allow me to add a few facts to the discussion of the editorial on the Marine Engine of the Future, in a recent issue of POWER.

A ship with an internal-combustion engine as a prime motor and electricity for the transmission of power was built in 1904 or 1905 by the Brothers Nobel Company, a large petroleum concern in the Caucasus, Russia. It has been giving entire satisfaction, and I believe that the company has now another ship of the same type. The first was called "Vandal." The question of constructing a big battleship, possibly of the Dreadnought type, with a liquid-fuel engine, and electricity for the transmission of power has been rather carefully studied out during the last two or three years by the Russian Marine Ministry, for it is believed that such a ship would have a very wide economic range of action, and would be able to go from European Russia to the Far East or half round the world without being dependent on any supply stations.

Ships moved by internal-combustion engines are rapidly crowding out steamers on the Volga, Caspian sea, and the vast system of rivers belonging to it in European Russia. It has caused already an important falling off in the business of the steamship companies in that region. The advantages claimed for the "heat-goers," as they are called, are cheaper fuel, minimum of waste in loading fuel and in feeding it to the engines, reduction in the number of men required in the engine room, and simplicity of operation. The amount of fuel used is about 25 per cent. less than in a steamer.

It must be borne in mind, however, that naphtha is at home on the Caspian sea, while coal has to be brought to it, and this fact may partly account for the rapid development of the internal-combustion engine, which only supplants the former crude-oil burning steamer.

L. GOLDMERSTEIN.

Champaign, Ill.

Belts Runs Off Pulley

If Mr. Berkley will clamp his belt and draw the stretched side up to the same tension as the good side, and cut his belt so the ends will come together square, I believe the belt will work all right. If he will put a piece of 6-inch belting around the center of the driven pulley it will help to keep the belt from running off.

THOMAS GORDON.

Cheyenne, Wyo.

Time of Exhaust Opening

In a recent letter, Mr. Buschman referred to the time of release or exhaust opening in high-speed engines; I assume he had the single-valve, automatic engine in mind.

In this class of engine the exhaust does not open abnormally early for late cutoff, but because a single eccentric is used, early exhaust and early cutoff are concomitant to each other. But I do not recall that anyone has claimed an advantage for this feature; in fact, early release is only a minor feature and a minor defect in a series of events in the action of the single-valve, shifting-eccentric gear. The seriously defective feature of this gear is that early exhaust closure must follow early cutoff and release, while just the opposite would best fit the physical requirements.

Compression in a reciprocating engine is usually opposed by the expanding steam on the opposite side of the piston, so that effective compression is only that which exceeds the opposing terminal pressure. Thus it is obvious that high terminal pressure will best be counteracted by heavy compression, due to early exhaust closure. As a matter of fact we are forced to be content with just the opposite state of affairs.

If a constant point of exhaust closure were attainable in this class of engine, much of the above mentioned difficulty would disappear, for the reason that the temperature of the cylinder at the time of exhaust closure has much to do with the shape of the compression curve; and as a high terminal pressure means a comparatively hot cylinder, this element tends automatically to fit the other two to each other—that is, if we have a single-valve engine in which the time of exhaust closure is constant, the amount of compression will be higher for late cutoff than for early cutoff because the entrapped exhaust in the first case will be hotter and drier, and instead of the necessity for heating the walls of the cylinder and reëvaporating a lot of moisture first, the pressure builds up from the time the exhaust valve closes. As an early cutoff means a low terminal pressure it also means a comparatively low cylinder temperature with its necessarily greater condensation the tendency of which is to nullify the effect of compression.

Is it not logical after considering the foregoing, to believe that if we could provide a gear which would close the exhaust at a constant point regardless of load variations, we would have attained a very nearly constant *effective* compression?

All of this is beside the mark as far as Mr. Buschman's inquiry, in the abstract, is concerned, but is offered to support my contention that the feature he mentions is *not* an advantage but a defect which is endured only because the designer cannot eliminate it.

E. G. TILDEN.

Downers Grove, Ill.

Speed-Reducing Gears

I am very much interested in speed-reducing gears and have followed the building and testing of the Melville-Macalpine gear very closely.

Comparing this gear with the one suggested by Mr. McArdell, in the January 18 number, one cannot help but see the various weak points in the construction of the latter.

Mr. McArdell has simply taken the old planetary type of gearing as formerly used on automobiles and added one more intermediate gear to secure an "equal" thrust. Everyone knows how noisy the earlier types of automobiles became after being a short time in service and I presume they also know the reason. Just as soon as a slight wear takes place in either the shafts or gears all alinement is lost and the fun begins. The only remedy is to renew the parts. This would be an expensive item in a gear large enough to transmit 6000 horsepower.

Another point against the McArdell type is the overhang of the large gear with the consequent trouble in the bearings. But the most serious point is the impossibility of adjusting any part to take up wear. I have seen the Melville-Macalpin gear transmit 6000 horsepower at 1500 revolutions per minute and the noise was nothing to speak of. The self-alining feature of this gear is the most valuable point in its favor as by this the pull by the teeth of each pinion is equal at all times and there is never any danger of one tooth doing more work than it was designed for. I should like to see more readers of POWER take up this discussion.

J. E. HINDMAN.

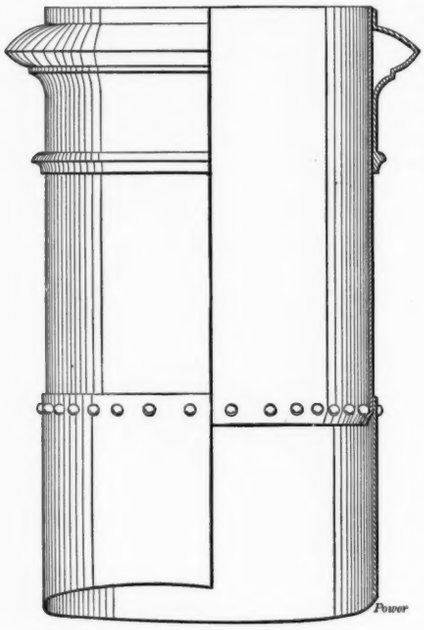
Wilkensburg, Penn.

Direction of Lap in Stack Joints

In the January 18 issue, Prof. John E. Sweet tendered further suggestions regarding the advantage of reversing the joints in metal stacks.

The present practice is to erect stacks with the laps on the outside facing down. In this letter it is admitted that stacks properly puttied at the joints and properly painted are exempted from the discussion. It is true that rust streaks when shown on stacks almost invariably start at the joints and are caused by water from the inside of the stack leaking through the joint.

In cases where stacks are constructed with the outside lap facing down, any water leaking through the joints and



JOINT SHOWING LIP ON INSIDE SHEET

showing rust on the outside of the stack is immediate notification to the owner that the stack is not in proper condition and needs attention. But, on the other hand, if the outside lap joint faces up and water leaks through the joints, what notification have we of the damage which is being done on the inside? In support of this, it can be cited that many steel stacks have been found to be badly rusted internally and the iron in poor condition even though the outside of the stack appeared to be all right and was well painted. This condition was due entirely to moisture having entered the stack in the form of either rain or exhaust steam turned into the stack as a means of disposing of the steam or accelerating draft.

The feature suggested by Professor Sweet, that of having a lip at the bottom edge of the three or four upper sheets suggests that he considers the liability of water entering a stack confined to the three or four upper joints. Would it not be reasonable then to suppose that it would be better practice to have the outside lap face down, as every rainstorm would wet the stack from top to bottom on the outside and all the water which ran down the stack on the outside would have to pass each lap and any leak existing would permit the water to enter the stack and extend down inside as far as the quantity of water permitted, whereas facing the outer laps down, the water would run freely down the stack without doing any damage.

As to the question of draft conditions, the turning in of the lip referred to by Professor Sweet, being confined to the three or four upper sheets, would have little or no effect as the draft of a stack is dependent more on its area at its base than at its top, due to the top being the point at which the motive force of the draft exists.

I believe that manufacturers are justified in building jointed stacks with the outer lap joints facing down and that no advantage can be secured by reversing the direction.

CHARLES H. PARSON.

New York City.

Boiler Room Ventilation and a Heating Question

I was much interested in the editorial on "Boiler Room Ventilation" which appeared in the January 18 issue. I have had much the same experience as was described. I am careful now to get my air supply from the open boiler-room windows and not from the interior of the building.

I am in charge of a large school building, and in cold weather it is a case of hustle in order to bring the temperature in the rooms up to the required point of 68 or 70 degrees by 9 a.m., when the outside air is at a temperature of zero.

As my three 80-horsepower boilers are well covered, as is also the steam piping, I am not losing any heat by drawing outside air into the boiler room, and I confess that I do not sit around the boiler room a great deal during cold weather.

In connection with this subject I would like a little light on a matter I have in mind. I have often entered the school rooms at 5 a.m. and found the temperature at 40 or 45 degrees in very cold weather, Monday mornings especially, after the building had been comparatively cool over Saturday and Sunday.

Now I have been able to raise the temperature from 45 to 60 degrees in less time than it took to raise it from 60 to 65 degrees. Of course, I have often heard of similar cases, but as yet I have never heard the explanation and I would be very glad to hear what POWER readers have to say in regard to this matter.

E. MANLEY.

Springfield, Mass.

Discrimination

I have read the article on Engineers' Wages in the January 11 issue, by Mr. Wells. What he has said in reference to the desirability of engineers being organized is very good. There are quite a number of engineers' organizations which have been formed for the purpose of bettering the conditions of the rank and file, but which seem only to benefit a few who happen to be "in right."

A young man who desired to better his position, applied to the labor bureau of the organization of which he was a member. He was informed that his case would be placed before the executive board for action. After the meeting he was notified that as soon as a position came to their notice which they thought him capable of filling, they would let him know. In about two weeks a representative of the organization called upon him and offered him a position so much inferior to the one he already had that he could not see any reason for taking it. Because he declined to accept this position he greatly offended the members of the board. He was offered another position about ten days later which called for a man to go around a hotel cleaning out traps and repairing leaks in pipes. The salary was $70 per month. He would be required to work 12 hours per day and 7 days per week. When he refused this he was practically dropped as far as the labor bureau was concerned.

While he was being offered these positions which no engineer would accept, not even one out of employment, other jobs were being passed out to a few favorites. The members of the executive board, however, think nothing of appointing the same men whom they have practically refused to help better themselves, on committees whenever they see fit, and they get pretty sore if the men claim that it is impossible for them to serve.

Labor unions and organizations should adopt the policy of treating all members in good standing alike, regardless of who they are or the positions they hold, whether they are officers or ordinary members and should do away with favoritism. They should adopt strictly business principles; then I think that they would be better off, for when an organization is ruled by "pull" it is bound to go wrong. This is why so many splits have taken place in engineers' associations.

Let every man stand pat and then the engineers of every State will be united and can compel recognition; the good men will be brought to the front, and those who do not care enough about the profession to keep it up to standard can be brought to time very readily or forced to quit the business.

H. H. BUCKLEY.

Brooklyn, N. Y.

Connecting Rod Crosshead Joints

In the January 11 issue, there appeared a description of a repair to a broken piston rod. The writer of the article wished to have opinions as to the comparative merits of the taper-and-keys style of connection between connecting rod and crosshead and the taper-and-threaded method of connection. In my opinion the taper-and-keys connection is the best design. The condition of the connection can always be observed, while in the other style this is not possible. The accident described was not due to design but to a misfit of the keys.

With the taper-and-keys style, the connection can be adjusted to changes in length when the clearance changes. Suppose we wish to make a tapped-and-threaded connection which to possess sufficient strength must be made 5 inches long. The tap is very liable to narrow down, in which event it is necessary to taper the threads on the connecting rod in order to let it into the tap for the proper length. Now if the clearance in the cylinder changes, the connecting rod will have to be backed out and it will be impossible to tell just how strong the connection is with the new adjustment. With the taper-and-keys connection, however, the condition of the joint can easily be inspected.

The tapped-and-threaded type of connection is all right for vertical engines but will not work well for Corliss engines.

WILLIAM STEWART.

Providence, R. I.

Trouble with Turbine Pump

The water is forced into a turbine pump by the pressure of the atmosphere. For water to flow into a pump a vacuum must be created at the impeller inlet greater than the available atmospheric lift, the additional head being necessary to overcome friction in the pipe and produce the velocity of flow. The denser the fluid, the higher the vacuum which the pump can produce.

Suppose the total suction lift is relatively small, say 10 feet, and there is present a considerable amount of air leakage. The theoretical atmospheric pressure being equivalent to 34 feet, there may still be sufficient head to give the same flow of fluid to the pump, but part of this is air and the quantity of water pumped will be decreased by the amount of air passing through with it. If more air leaks develop so that the suction lift is equivalent to 20 feet, the quantity of water handled will be still further decreased. In addition, the available pressure which forces the water to the pump is less by 10 feet; hence a lesser velocity will be produced in the suction pipe and less water taken in by the pump.

If the suction head is still further increased the velocity and quantity of water discharged decrease until the column finally breaks and the pump loses its water.

If the air and water are not well mixed and passed through the pump together, the air may accumulate at the center of the impeller and break the vacuum. Such a sudden failure is not at all uncommon and is often puzzling to the operator, who does not understand why the pump should suddenly "lie down."

L. CORWIN.

Newburgh, N. Y.

Flue Areas

After reading over several times the criticism of Mr. Cederblom on page 134, of a little article by myself on the subject of flue areas, I am still not positive whether he agrees or disagrees with me on some points. However, I will assume that the printer was in error when Mr. Cederblom is made to say, "I do not think we can go by the cross-sectional area of the tubes in determining the proper area of the breeching," for he later repudiates such a statement by advocating this method of determining breeching areas. Mr. Cederblom states that he desires to know how much heating surface the writer assumes per boiler horsepower, in order to have the capacity of a boiler vary directly with its length; to this question I reply that the amount of surface assumed per horsepower is immaterial, for it is only necessary to assume any fixed amount to produce this relation. With the same diameter of shell and the same number and size of tubes, a horizontal tubular boiler of any length will increase or decrease its water-heating surface uniformly for each foot of length added or substracted, and since all boiler ratings are based on some fixed amount of water-heating surface per horsepower, the rated capacity of such a boiler will vary directly as its length, and this rate of variation is entirely independent of the amount of heating surface assumed to be a horsepower, whether it be 5 or 10 square feet. If the water level in a vertical boiler be maintained at a fixed distance below the upper tube sheet, the rated capacity of such a boiler will vary directly as its length, for the same reasons that apply to the return tubular type. Mr. Cederblom evidently desires to distinguish between the values of different parts of the water-heating surface in rating boilers, a thing which would doubtlessly be desirable but which is impossible in the present state of practical engineering, and attempts to do this up to the present time have caused considerable grief to those manufacturers who have endeavored to sell their patrons a smaller amount of heating surface per horsepower than given by their competitors, using the excuse that their heating surface is much more effective.

All of Mr. Cederblom's arguments on this point have practically no bearing on the real object of my article, which was to give a correct idea of the proper flue areas required per boiler horsepower, under average conditions of draft intensity. It was plainly stated that the correct method of proportioning areas of breechings, was on the basis of the volume and velocity of the gases to be handled, and this is still absolutely true, regardless of Mr. Cederblom's criticism. In order to make a table applicable to average conditions, it was necessary to make certain assumptions regarding the intensity of draft, and the basis upon which these assumptions were made is clearly explained in the article. The article contains nothing that might be considered as original, but, as was fully explained, it was based strictly on the formula for chimney areas given by Prof. William Kent. How Mr. Cederblom can imagine that it should require a less area of flue to handle the products of combustion from a fixed amount of fuel over a given number of square feet of heating surface, if passed through a less number of longer tubes than through a larger number of shorter tubes is beyond my ability to perceive, and if he has any real reasons to advance why this would represent good design, he will doubtlessly be conferring a favor on other readers of POWER besides myself, by putting them forth.

J. E. TERMAN.

New Haven, Conn.

Cylinder Lubrication

I note that one of the contributors to the cylinder-lubricant discussion states that he has used Capitol cylinder oil in his engines successfully while they were operating with steam at 100 pounds pressure, but as he intends to increase the steam pressure to 125 pounds he expresses the fear that he will be compelled to use another lubricant. I can assure him that he need have no fear on that score. If the lubrication has been satisfactory while using steam at 100 pounds pressure, it will continue to be so with steam at 125 pounds pressure, using the same brand of oil. Steam at 100 pounds pressure has a temperature of 338 degrees Fahrenheit and at 125 pounds pressure a temperature of 352 degrees, a difference of 14 degrees. It has been said, "To secure the best results from a cylinder oil it should be dropped into the steam as the steam journeys to the cylinder, and by so doing the oil becomes atomized, not vaporized, but broken into small atoms, and in the form of a spray is carried to the valves, etc." As the oil mentioned has a vaporiz-

ing point considerably above the temperature of the steam the increase in the temperature of steam from 338 to 352 degrees will not cause it to vaporize or decompose.

I have been interested in the description given by A. J. Dixon of his experience with cylinder lubricants following the change made at his plant from the use of saturated to superheated steam. From Mr. Dixon's description of the troubles experienced, I am inclined to the belief that when the change was made from saturated to highly superheated steam a slightly increased expansion of the wearing parts of the engine, such as valves, valve seats, piston and rings took place, thereby increasing the friction. While he was experimenting with different kinds of oil it is probable that there was a gradual wearing down of the parts affected by the increased temperature of the steam, with the result that at the time the oil said to contain the special ingredient was placed in service the wearing parts had been so reduced in size by friction that they worked as freely with superheated steam as they had formerly done with saturated. About eight years since, an Eastern firm of engineers secured the right to make and sell in this country a superheater of German invention. Some time after they had commenced to market the superheater the president of the firm advised me that they were experiencing considerable trouble in the lubrication of the engines where the superheater had been installed. He said that they had tried and condemned "600 W" cylinder oil, and further stated that they had sent to Germany for the kind of oil the inventor of the superheater used, and since its arrival they had by its use overcome the lubrication trouble here. A sample of this oil was secured and examined. It was found to be the very same brand of oil they had condemned. A further investigation of the matter showed that the trouble attributed to faulty lubrication was due to the friction caused by the increased expansion of the moving parts of the engine that had come in contact with the steam at higher temperature.

I once saw a pyrometer registering 665 degrees in the steam chest of an engine that was being satisfactorily lubricated with "600 W" cylinder oil.

This oil, which vaporizes at a temperature below that shown on the pyrometer, remained in the cylinder and steam chest in a fluid state. That the oil remained fluid was due to the same principle whereby water changes into steam in the atmosphere at a temperature of 212 degrees, but when under a pressure of, say, 75 pounds to the square inch, requires a temperature of 300 degrees to change it into steam. An oil may vaporize in the atmosphere at 600 degrees, yet a very much higher degree of heat would be required to vaporize it in a steam cylinder under, say, 100 pounds pressure of steam.

I suggest to Mr. Dixon that he again try the same brand of cylinder oil and report what success he meets with.

CHARLES HUGILL.

Bellevue, Penn.

Engineers' Wages

I have read with much interest the letter by C. L. Chadwick in the January 11 issue of POWER, on the subject of "Engineers' Wages." This topic is always open for argument. Both in individual cases and as a class, it is always up to a man to sell his labor for the highest price obtainable. My feeling, when I read an article on the subject, is that I would like to help smooth out some of the dissatisfaction felt, for it seems to me that engineers, as a whole, are paid a salary up to the average of other working men and the fact that we only see three or four letters a year in a paper like POWER, which has a circulation of 35,000 to 40,000 copies, makes me think that engineers as a class are not borrowing much trouble about the matter.

In the majority of complaining letters on the subject the writer compares the wages of engineers with those of masons and hodcarriers; Mr. Chadwick mentions the machine-shop foreman. I do not think the comparison between engineers and masons a good one. It is true a mason works only eight hours a day, but, as a rule, he works the whole eight hours and does not loaf, while the majority of engineers have time to sit down and visit and read the daily papers and even books while on duty. How many engineers are there that work nights that do not find time even to sleep a little? One of the attractive points about the work of an engineer is that the work is comparatively light and in a plant in which the engineer has to keep going all the time there must be something radically wrong. Either it is the superintendent, the condition of the plant or the fault of the engineer himself. Trouble from any of these sources will right itself in time, for it is not to the interest of the owner to have the engineer on the go all of the time as it is an indication that the owner is losing money on bad operation.

Another point, the mason works by the hour and out doors where weather conditions interfere with steady work and he is out of his trade two or three months each winter. His jobs are short during even the best seasons and sometimes several days and even weeks elapse between jobs.

About the comparison with the shop foreman, from what I have seen, in any place where the business is big enough to maintain a repair shop it also can afford a chief engineer in charge of its boilers and engines and the chief engineer's salary compares very favorably with the salary of the shop foreman.

I think Mr. Chadwick is wrong when he infers that the engineer takes his responsibility and troubles home with him, and that the shop foreman does not, for it is human nature to think that our own personal troubles are greater than those of the other fellow. While a man to be a good engineer should have ability and should be willing to shoulder responsibility, it is bad business for an engineer to stay at his work all the time and to consider his responsibility all the time. He will get along better if when his quitting time comes, he leaves all his troubles in the plant and goes home and has a good supper and loses himself in a good story or song, or listens to a band or tumbles the kiddies about the floor. A change of pasture makes fat calves and, likewise, a change of mind and thought action stimulates mental ability.

I have been an engineer several years but have not as yet had a chance to try an eight-hour day. Mine have all been 10-, 12- and 13-hour days. The wages compare favorably with other engineers and I think with those of other lines of work. There are still more rungs on the ladder and I am going to keep trying to get up higher where the hours are better and where wages turn to salary.

JAMES W. MORGAN.

Chicago, Ill.

Location of Throttle Valves

There have been several contributions in POWER during the past few months regarding the proper location of the throttle valve of a Corliss engine. In the discussions, I have not yet seen anyone advocate the location of the throttle valve in what I believe to be the only proper place for it. It should be placed on the cylinder so that the handwheel will be directly over the bonnet of the head-end admission valve or over the stuffing-box gland of the admission valve. When the throttle valve is mounted in this manner on an engine cylinder and the operator wishes to stop or start, he stands at the side of the dashpot, his left hand on the throttle handwheel and his right hand on the starting bar. He is now in a position to handle the engine at his will and does not have to move from his position until he has turned on a full head of steam. Furthermore, he is standing to one side of the cylinder head, and in no danger of being hurt if the piston should drive out of the head end, as pistons sometimes do.

To my way of thinking, the throttle valve could not be put in a safer, or a handier place.

A. I. HAIGHT.

Kalamazoo, Mich.

Power for Industrial Establishments

Discussion of Papers Presented at the Boston Joint Meeting of the American Society of Mechanical Engineers and the American Institute of Electrical Engineers

At the joint meeting of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers, held at the Boston City Club, February 16, 1910, three of the papers, presented by Professor Jackson, Charles T. Main and R. S. Hale, took up the question of the advantages and disadvantages of concentration in the generation of power for industrial establishments. Professor Jackson indicated some of the advantages of concentration without of necessity indicating the desirability of carrying it quite so far as Mr. Hale's recommendations, which pointed to the generation of power by public-utility enterprises exclusively. Mr. Main pursued a middle course, indicating that there were limitations to the concentration of power generation, while, by inference, indicating that in many cases the process of concentration may be desirable. An abstract of these three papers appeared in the March 1 number of POWER, and the discussion which took place at the meeting is presented in the following:

J. C. Parker: Public-service enterprises nowadays must, without exception, dispose of their power on a system which in some form or other is a copy of the Doherty system of a fixed charge per kilowatt of maximum demand, plus a unit charge per kilowatt-hour of energy consumption. The customer of a public-service plant may, at any time, make improvements in his factory operation or motive power, whereby his maximum demand may be cut down or materially reduced, and therefore the fixed cost for the maximum demand eliminated from his power bills. With a private plant on his hands, this could not be done nor would it be dependable. The investment is already in and the labor must be paid anyhow, and therefore the reduction in maximum demand will not throw off anything from the fixed cost. Where power is purchased on the other hand, the customer essentially has the advantage of a flexible and variable investment charge carried for him by a public-service enterprise. It may be said that it is to the interest of the owner of a private plant in a growing concern to do everything in his power to improve his load factor by keeping down the maximum demand, so as to prevent the necessity for additional investment in the power plant as the business grows. This condition, however, does not obtain in practice. Seldom in the early stages of a business development is it apparent that some little trouble in load-factor improvement is justifiable and conditions continue to follow their unrestricted course until the capacity of the power plant is reached. Then the cost of making changes which would improve the load factor has accumulated to such a large sum as to be quite prohibitive. The result is that the owner is compelled to extend his plant.

The same considerations apply in the matter of efficiency as in load factor. A private-plant owner has as an inducement to improve the efficiency of his power-utilizing machinery or motors, only the coal-pile saving, which is probably not more than 10 per cent. of the average cost of power. If, on the other hand, he were purchasing his power under a satisfactory form of contract from an outside company, it would mean a 10 per cent. reduction in his bills, since it would reduce his maximum demand and his kilowatt-hour consumption alike, thereby enabling him to make the cost economy equal to the power economy.

One other phase of the matter of flexibility in the use of purchased power is that the owner of a private plant is unable to take advantage of the progress in the development of power-plant equipment, as distinguished from power-utilizing apparatus. Improvements have gone on at a rapid rate during the last twenty years and seem to show no abatement at the present moment. It seems to the speaker that were he a power user, he would prefer to have the opportunity to benefit by all the improvements in the art as they come along, rather than to install today a plant which, five years from now, would be of an obsolete type. These improvements can be made by the public-service companies, since, with their multiplicity of units, they can make their improvements in line with the latest developments.

These considerations would indicate that the manufacturer contracting for his power supply, so far from being tied up to some exacting contract, is relieved from being tied up to what may be a bad investment, and is in a position to utilize as it comes every advance in the machinery peculiar to his own process in motors and through the supply companies in generating apparatus.

The speaker's personal experience indicates very strongly the necessity for stopping centralization much short of what has obtained in the past. There is, as pointed out by Mr. Main, a certain class of business which public-service enterprises cannot possibly hope to secure. Hotels have an all-year and an all-day demand for heat. Office buildings have an all-day demand for heat during at least eight months of the year. If supplied with power by public-service companies, they must not only pay for the fuel burnt in the central station, for the labor and supplies in a central station, for the power- and boiler-equipment charge, but they must, in addition, pay for the extra investment to take care of from 10 to 20 per cent. drop in the feeders, for the power lost in these feeders, for the use of underground mains with franchise factors thereon; but over and above they must themselves maintain a nearly identical boiler equipment and pay for nearly identical fuel, water, boiler-room labor, and boiler-room supply expenses, which put the public-service enterprise without the pale.

There is also a commercial feature involved. The man contemplating a private plant for such a service always underestimates his coal consumption, whereas the central-station company knows what its coal consumption is. If, then, we are to talk power purchase to a man who estimates that he can develop a kilowatt-hour on 1½ to 2 pounds of coal at his switchboard and supply its byproduct heat thereby, and if we have to tell him that under a power-purchase arrangement he will have to pay for, in addition to his heating coal, 3½ to 4 pounds of coal delivered in his building in the form of electrical energy, we are practically tripling his fuel bill. This, of course, is a fallacy on the part of the man talked to, but it is a condition nevertheless which all sorts of missionary efforts fail to eradicate.

In closing, the speaker said a few words about the desire of the central-station companies to secure the big business. This business is very attractive sentimentally, and for advertising purposes it is very excellent, but it is questionable whether the effort so expended is so profitable as the effort put in to get the smaller business. It is true that central-station companies have not done enough in making their rate systems logical and favorable to the big plant work; but it is questionable whether the big plant is *per se* cheaper to supply than a number of comparatively small plants, since a group of small customers will have a very small diversity factor, while all other expenses of serving them, with the exception of the service wires, meters and clerical work, are practically identical. Therefore, it appears that the large customers demand for the same individual load factor a greater equipment per kilowatt-hour than do the small ones,

whose diversity factor may be much larger.

Charles B. Burleigh: It has not been until within the last few years that those having in hand the establishment of manufacturing plants requiring the use of any considerable amount of power, would not have sacrificed many other desirable manufacturing advantages to secure a location where water power was available. The last few years, however, have produced marked changes in these conditions, and, as stated by Mr. Jackson, "the large steam turbine may nearly rival the gross cost per kilowatt-hour of energy delivered at the switchboard." In other words, Boston, New York, Chicago, St. Louis, and hundreds of other large cities throughout the country are today occupying the same relation to the power consumer as though an unlimited, never-failing, never-varying water supply for power were at all times available, and its use for manufacturing purposes not hampered by any abnormal development charge or subject to any excessive depreciation or climatic uncertainties in order to make its use available for his purpose.

These conditions, together with the comparatively recent advancement in the design and operation of high-tension electric machinery have not only vastly increased the economical radius of both steam and hydraulic development, but are making valuable water privileges for power purposes which have heretofore been considered not worth developing, as well as making desirable for manufacturing purposes locations which could not previously be considered.

Due in a large measure to the foregoing conditions, the time is fast approaching, if it has not already arrived, when few, if any, manufacturers having use for power in large or small quantities within a radius of 10 or even 20 miles of a large distributing plant, can afford to devote the necessary time, energy and capital to the production of his own power.

Consider for a moment what these conditions are capable of doing for Fall River, where all of the many thousands of tons of coal burnt per annum in her immense textile establishments have to be carted uphill at an expense of from 30 to 75 cents per ton, and also at New Bedford, where, notwithstanding the fact that it is located on tidewater, over 80 per cent. of all the fuel burnt in the city for power purposes is teamed at an average cost of some 30 cents per ton, and at Lawrence, Lowell and Holyoke, where in each case a central electric-power plant, ideally located with reference to the most economical utilization of their water powers, would not only serve their present available market but would more than double it; and the land now occupied by canals would be made available for the location of additional manufacturing industries, while the land values and savings in canals and water-wheel upkeep would very nearly, if not quite, pay for the developments, to say nothing of the immense benefit that would accrue to the several communities.

The speaker indorsed the statement made in Mr. Main's paper that the cost of power in a textile mill, as well as in many other classes of manufacture, is but an incident to the ultimate results, "and is such a small percentage of the cost of the product that it is worthy of little or no consideration."

In considering the deciding factors, reliability is of prime importance, as the fixed charges in an industrial plant are continuous, and any interruption in or stoppage of production makes a great difference in the earnings of a given investment.

In comparing the reliability of operation of a manufacturing establishment furnishing its own power, as compared with one receiving its energy from a central power plant, the speaker said that not 10 per cent. of the manufacturing establishments, large or small, have duplicate prime movers, while central power-distributing plants have many similar units, the overload capacity of a small percentage of which would be equal to the full capacity of any single unit. The average isolated power plant being but an incident to the main object of the business, is given less attention by the management than is similar apparatus in a central plant, where upon the uninterrupted and economical production of power wholly depends the success of the object of the investment made, for which reason there can be no question with regard to reliability up to this point.

It may be regarded that the transmission line from the central station to the point of delivery is an item of unreliability not necessary to consider in connection with the isolated plant. It is necessary to consider the location of the central station. In order to equitably do this, we must give some consideration to the items of difference between water and steam stations. With regard to the reliability of output from the stations, there should be no material difference, because if there be any source of anticipated unreliability from the water power, such as high or low water, or any interruption to the service, we may consider that, in order to make it commercial, it has been provided with a steam relay of such capacity as will meet any possible contingency.

The steam station is, or should be, so located that its source of fuel and water supply can under no conditions be interfered with, while the hydraulic station must of necessity be located with reference to water supply to which the source of fuel supply is secondary. In fact, the location of the hydraulic station is comparable to the old water-operated manufacturing plant, in which all other considerations as regards location are secondary to the hydraulic conditions.

The location of the steam-operated isolated manufacturing plant is selected in accordance with its market, source of supply of raw material, ease of shipment, availability of suitable help, and in some industries on account of climatic conditions. Or, in other words, its source of fuel supply is of minor importance.

It would therefore seem apparent that the transmission of energy by electricity over wires permanently and ruggedly installed, and not liable to be affected by strikes, hold-ups, washouts, snow storms, floods and other natural causes to nearly the extent that the transmission of fuel is, demonstrates this last item to be fully as, if not more, reliable than the others.

Flexibility is another item worthy of consideration. This item is one of admitted superiority of the electrical drive over the mechanical drive, and as the central-station drive must of necessity be electrical, the comparison of this feature can only be between the electrically operated isolated plant and the central station, and a comparison on this basis is all in favor of the station.

Additions and alterations can be made without in any way interfering with the continuity of operation, and changes in products and capacity have no effect on operating efficiency. Also, less financing for a given output is required.

Results from an investigation made by Mr. Burleigh of a large mill using power from a central station led to the following conclusion: That maximum production is the item of paramount importance to the manufacturer, which is to a large extent subservient to and dependent on reliability and flexibility, all of which are best conceived by the central station at costs, at least commensurate with the results obtained.

Norman T. Wilcox brought out the idea that the necessity for extensive relay was less in large central stations than in an isolated plant. He also contended that less depreciation could be charged against the well cared for central-station equipment than against the mill plant.

The superior economies of the modern central station are due to constant and close hourly and daily checking, which is a practical impossibility in the case of the mill plant where the steam is going from the common boiler equipment for use in all parts of the mill yard. In most cases the advantages arising from the use of exhaust steam where there is a steady need for it the year round, cannot successfully be questioned. It should not be forgotten, however, that there are some disadvantages in distributing low-pressure steam over a considerable area, such as might be present in the case of a large mill plant.

H. B. Emerson considered that the matter of concentrating the generating equipment must be decided by individual conditions. The use of exhaust steam in certain plants will be a predominant factor in deciding for the isolated station. In some plants, of course, the power is a small item compared with the other cost of manufacture, but in many plants it is the leading factor, and whether large or small it is looked after very carefully in the uptodate plants. If central-station service can show a saving to the owner, any broad-minded man will adopt it. However, he must be shown. He knows what his tools, labor supplies, repairings, etc., cost him, and if he finds that he can produce his power for one cent per kilowatt-hour, he will not pay a central station two cents for it.

H. W. Peck: These papers are much more general than I could wish. It is noticeable in both Mr. Jackson's and Mr. Main's papers that they give practically the best performance of the machinery which they are discussing, but do not state what they have found to be or believe to be the average performance. For example, Mr. Jackson says, "the cost is probably fully that large," and again, "the cost is ordinarily much higher." I would suggest that in discussions of this kind the cost and other items regarding performance be reduced to the basis of the kilowatt-hour, as this basis will apply in the majority of cases. Thus, Mr. Jackson's "round estimate of the cost of power in machine shops and the like is $60 per horsepower-year" becomes three cents per kilowatt-hour. His cost of 65 cents and one cent per indicated horsepower-hour, which he increases by 50 per cent. for mechanical distribution, can with equal correctness be increased by 50 to 70 per cent. to give the cost per kilowatt-hour at the switchboard, enabling direct comparison with central-station power. Mr. Main's figures of pounds of coal per horsepower per hour might be increased from 1.75 and 3 to about 2.95 and 5.05 pounds per kilowatt-hour at the switchboard.

I would take exceptions to the proposition that reliability is of secondary importance. This is certainly far more important for a small plant which would be very seriously crippled by the breakdown of one unit than for a large central station with so many units that the load of any one could be easily carried by the remaining units. It seems poor judgment to skimp on the power plant.

In my experience with industrial plants, there is a very marked seasonal variation, and in most cases a steady growth in power requirements. In our experience also, the lighting of the establishments amounts to from 10 to 25 per cent. of the power requirements, and is of short-hour use. This decreases the load factor much below that given in the paper. This brings to mind another advantage which the central station possesses. Its growth has been steady but gradual, and it had the opportunity of making its additional equipment of the modern form. This most efficient equipment can be used for long-hour use, while the less efficient and less valuable machines are thrown in for the peak load.

Neither paper considers the item of profit which should be earned on the power-plant investment. Mr. Main passes very lightly over the matter of supervision on the part of the manager. I have found that the managers are required to expend considerable of their time and thought on the power problems. These managers are experienced in business, but are not engineers, and their time is expended to small advantage in power questions.

As to the division of central-station cost, I would say that the production cost is about one-half, the distribution about one-third, and the general expenses, including advertising and commercial expenses, about one-sixth. In the specific case of the smallest customers who use just enough power to pay the minimum charge of $1, the central-station companies certainly lose money. For a large customer, the meter costs are a negligible part of the total expense. I have yet to find any industrial establishment that knows even within approximate limit the cost of its power. Such costs were recently promised me by one establishment with the assurance that they had them exactly, and that it would be a simple matter to take them from the books in shape for me to use. They have since told me that it will mean several months' work to get these data. They are quite surprised at the manner in which the costs have been entered.

R. D. Wolf: As pointed out in Mr. Main's article, the mill which can use all of the waste products from the power plant will have the lowest cost, and this same condition exists when the power plant is operated by a central-station company, and that company is in a position to sell its waste products.

There are several conditions existing which make the operation of the decentralized heating and power plants particularly attractive. The operating conditions are determined not by a widely fluctuating load, but by a fairly steady heating load. On account of this improvement in the load factor on a plant, it is unnecessary to carry large reserved power units for peak loads, and the plant can be operated at or near its point of maximum efficiency the greater part of the time. As the plant is necessarily a noncondensing one, complicated auxiliary apparatus is dispensed with, and a simple type of installation put in which can be operated by comparatively unskilled labor. This labor can be used as efficiently in a medium-size plant of this type as the higher grade of labor is used in a much larger condensing plant. When the condensing plant can be so located as to handle a group of buildings of diversified character, the diversity factor of the steam load will be such that the resultant load on the plant will have only a comparatively small variation.

These decentralized plants affect the distribution charges in several ways. Cost of distributing system is less, and there is better distribution, better service, less condensation in the distributing system, and the system can be made more flexible.

The operation of plants of this character will enable a central-station company to operate certain of their plants under the same conditions which Mr. Main has found to be most economical for textile mills; that is, use can be made of all the waste products of the plant. I think that the manufacturer can be shown the value of power, and these waste products are more to him than the 5 per cent. value given by Mr. Main.

A. C. Grass (by letter): Mr. Main states that the chief items of cost in textile mills are material and labor. Such mills, therefore, should locate in or near cities where cheap labor can be obtained instead of locations where cheap power can be obtained. Also the mill owner should welcome every improvement which will give steady uniform power, as this means increased output without increased labor. Owners should be willing to pay for the power which enables them to obtain an increased output. Central stations, because of their reserve equipment and multiplicity of distribution lines, can guarantee continuous service. Mr. Hale expresses the situation very well when he says that central stations have no cheap unreliable power for sale.

Regarding the question of power factor, textile mills, I am informed, do not run ten hours per day every working day in the year, but are shut down about two weeks for inventory and repairs, and often Saturday afternoons in the summer time. Recording wattmeters which have been installed on the switchboard of industrial plants show that the employees do not get to working until 7:30, and that the best work or the most power is taken between 10 o'clock and 11 o'clock. After that time, the load gradually falls off until noon. The same thing happens in the afternoon, except that the load seldom goes as high as in the morning. These facts, when taken into account, bring the load factor of the mill below that of the large central station. The basis of figuring the cost of power at $33 per kilowatt-year of capacity of the plant is not an accurate method, as most plants have a capacity larger than their average load, and some few will run overload part of the time. The proper basis is the maximum load.

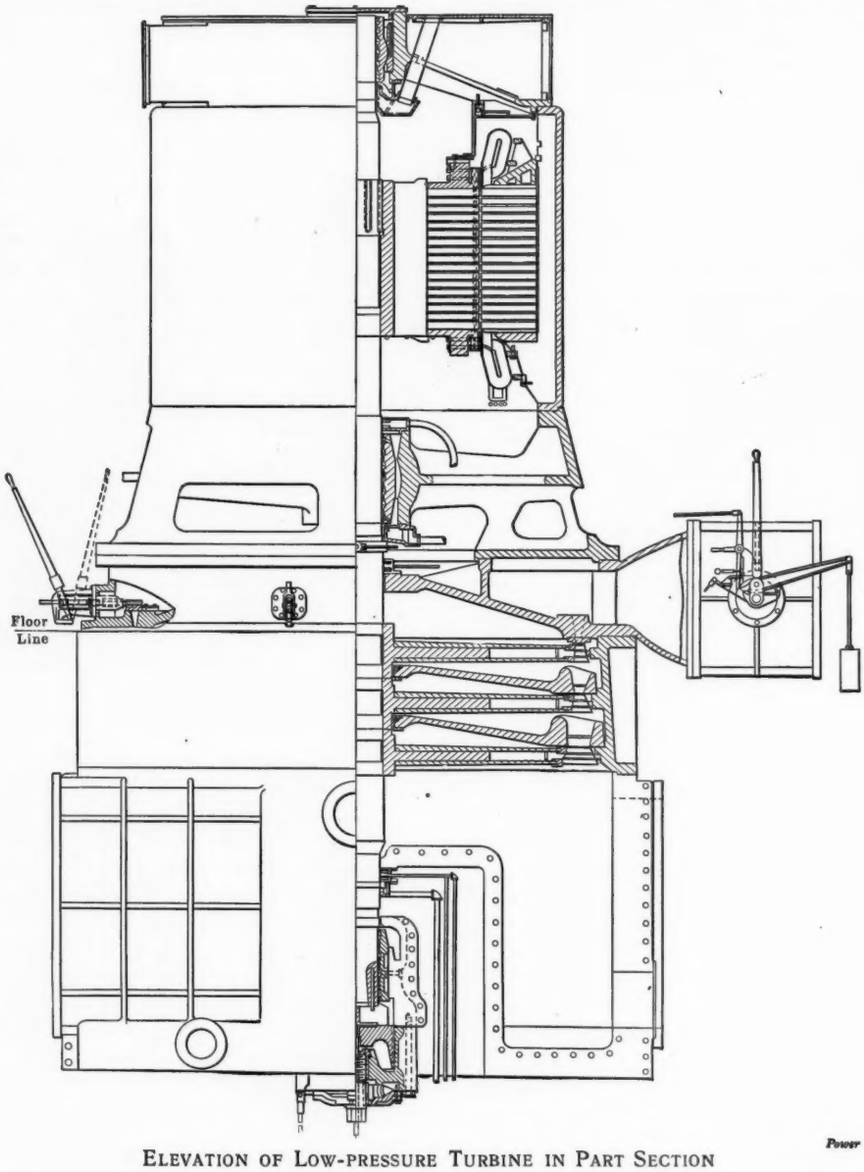
Test of 15,000 K.W. Engine-Turbine Unit

Low-pressure Turbines Connected to Large Compound Corliss Engines Increase Capacity of Plant 146 Per Cent. and Make 25 Per Cent. Reduction in Fuel Burned

*BY H. G. STOTT and R. J. S. PIGOTT**

During the year 1908 it became apparent that owing to the fast increasing traffic in the New York subway, it would be necessary to have additional power available for the winter of 1909-1910.

The power plant of the Interborough Rapid Transit Company, which supplies the subway, contains nine 7500-kilowatt (maximum rating) engine units, besides three 1250-kilowatt 60-cycle turbine units which are used exclusively for lighting and signal purposes.



ELEVATION OF LOW-PRESSURE TURBINE IN PART SECTION

The 7500-kilowatt units consist of Manhattan-type compound Corliss engines, having two 42-inch horizontal high-pressure cylinders and two 86-inch vertical low-pressure cylinders. Each horizontal high-pressure cylinder and vertical low-pressure cylinder has its connecting rod attached to the same crank, so that the unit becomes a four-cylinder 60-inch stroke compound engine with an overhanging crank on each side of a 7500-kilowatt maximum rating 11,000-volt, three-phase, 25-cycle generator. The generator revolving field is built up of riveted steel plates of sufficient weight to act as a flywheel for the two engines connected to it. This arrangement gives a very compact two-bearing unit. The valve gear on the high-pressure cylinders is of the poppet type, and on the low-pressure of the Corliss double-ported type.

The condensing apparatus consists of barometric condensers, arranged so as to be directly attached to the low-pressure exhaust nozzles, with the usual compound displacement circulating pump and simple dry-vacuum pump.

These engine and generator units are in general probably the most satisfactory large units ever built, as five years' experience with them has proved; their normal economic rating is 5000 kilowatts, but they operate equally well (water rate excepted) on 8000 kilowatts continuously.

In considering the problem of how to get an additional supply of power, every available source was considered, but by a process of elimination only two distinct plans were left in the field.

The electric transmission of power from a hydraulic plant was first considered, but owing to the high cost of a double transmission line from the nearest available water power, and the impossibility of getting reliable service (that is, service having a maximum total interruption of not more than ten minutes per annum) from such a line, further consideration of this plan was abandoned.

The gas engine, while offering the highest thermodynamic efficiency, at the same time required an investment of at least 35 per cent. more than an ordinary steam-turbine plant with a probable maintenance and operation account of from four to ten times that of the steam turbine.

The reciprocating-engine unit of the same type as those already installed, was rejected in spite of its most satisfactory performance, on account of the high first cost and small range of economical operation. The economic limits of operation are between 3300 and 6300 kilowatts; beyond these limits the water rate rises so rapidly as to make operation undesirable under this condition, except for a short period during peak loads.

The choice was thus narrowed down to either the high-pressure steam turbine or the low-pressure steam turbine. There was sufficient space in the present building to accommodate three 7500-kilowatt units of the high-pressure type, or a low-pressure unit of the same size on each of the nine engines, so that the questions of real estate and building were eliminated from the problem.

The first cost of a low-pressure tur-

*Mr. Stott is superintendent of motive power for the Interborough Rapid Transit Company, and Mr. Pigott is one of his associates. The paper was presented at the March meeting of the American Society of Mechanical Engineers at New York.

bine unit is slightly lower than that of a high-pressure unit, due to the omission of the high-pressure stages and the hydraulic governing apparatus, but the cost of the condensing apparatus would be the same in both cases. The foundations and the steam piping in both cases would not differ greatly. The economic results, so far as the first cost is concerned, would then be approximately the same, if we consider the general case only; but in this particular instance the installation of high-pressure turbines would have meant a much greater investment for foundations, flooring, switchboard apparatus, steam piping and water tunnels, amounting to an addition of not less than 25 per cent. to the first cost.

The general case of displacing reciprocating engines and installing steam-turbine units in their place was also considered. The best type of high-pressure turbine plant has a thermal efficiency approximately 10 per cent. better than the best reciprocating-engine plant, but the items of labor for operation and for maintenance, together with the saving of about 85 per cent. of the water for boiler-feed purposes and the 10 per cent. of coal, reduce the relative operating and maintenance charges for the steam-turbine plant to 80 per cent., as compared to 100 per cent. for the reciprocating-engine plant.

Assuming that the reciprocating-engine plant is a first-class one and has been well maintained, about 20 per cent. of its original cost (for engines, generators and condensers) may be realized on the old plant and so credited to the cost of the high-pressure turbine plant. But on the other hand, if the high-pressure turbine installation is to receive credit for the second-hand value of the engines, it must also have a debit charge for 100 per cent. of the original reciprocating-engine plant which it displaced. The relative investments, therefore, upon this basis would be approximately equal for the high-pressure or the low-pressure turbine; but 80 per cent. of the cost of the original engine plant would have to be charged against the high-pressure turbine plant, as against an actual increase in value (to the owner) of the engine by reason of its improved thermal efficiency, due to the addition of the low-pressure turbine.

The preliminary calculations, based upon the manufacturers' guarantees for the low-pressure and high-pressure turbines, showed that the combined engine-turbine unit would give at least 8 per cent. better efficiency than the high-pressure turbine unit, so that it was finally decided to place an order for one 7500-kilowatt (maximum rating) unit, as by this means we would not only get an increase of 100 per cent. in capacity, but at the same time give the engines a new lease of life by bringing them up to a thermal efficiency higher than that attained by any other type of steam plant.

The turbine installed is of the vertical three-stage impulse type having six fixed nozzles and six which can be operated by hand, so as to control the back pressure on the engine, or the division of load between engine and turbine. An emergency overspeed governor, which trips a 40-inch butterfly valve on the steam pipe connecting the separator and the turbine and at the same time the 8-inch vacuum breaker on the condenser, is the only form of governor used. The footstep bearing, carrying the weight of the turbine and generator rotors, is of the usual design supplied with oil under a pressure of 600 pounds per square inch with the usual double system of supply and accumulator to regulate the pressure and speed of the oil pumps.

The condenser contains approximately 25,000 square feet of cooling surface arranged in the double two-pass system of water circulation with a 30-inch centrifugal circulating pump having a maximum capacity of 30,000 gallons per hour. The dry-vacuum pump is of the single-stage type, 12 and 29 by 24 inches, fitted with Corliss valves on the air cylinder. The whole condensing plant is capable of maintaining a vacuum within 1.1 inch of the barometer when condensing 150,000 pounds of steam per hour when supplied with circulating water at 70 degrees Fahrenheit.

The electric generator is of the three-phase induction type, star wound for 11,000 volts, 25 cycles and a speed of 750 revolutions per minute. The rotor is of the squirrel-cage type with bar winding connecting into common busbar straps at each end. This type of generator was chosen as being specially suited to the conditions obtaining in the plant.

With nine units operating in multiple, each capable of giving out 15,000 kilowatts for a short time, operating in multiple with another plant of the same size, it is evident that it is quite possible to concentrate 270,000 kilowatts on a short circuit. If we add to this, synchronous turbine units of 7500 kilowatts capacity, which, owing to their inherently better regulation and enormous stored energy, are capable of giving out at least six times their maximum rated capacity, the situation might soon become dangerous to operate, as it would be impossible to design switching apparatus which could successfully handle this amount of energy. The induction generator, on the other hand, is entirely dependent upon the synchronous apparatus for its excitation, and in case of a short circuit on the busbars would automatically lose its excitation by the fall in potential on the synchronous apparatus.

The absence of fields leads to the simplest possible switching apparatus, as the induction generator leads are tied in solidly through knife switches, which are never opened, to the main generator leads. The switchboard operator has no control whatever over the induction generator, and only knows it is present by the increased output on the engine-generator instruments.

The method of starting is simplicity itself—the exciting current is put on the engine generator *before* starting the engine, and then the engine is started, brought up to speed and synchronized in exactly the same way as before. While

TABLE 1. TEST OF ENGINE ALONE.

NUMBER OF TEST	ENG. LOAD K.W.	STEAM PR. Gauge Lbs.G.	STM TEMP. °F	STM SUPER-HEAT °F	RECEIVER PR Gauge (from Temp Tables) Lbs G.	VACUUM Std. 29.92" Bar "Hg.	QUALITY STM %	WATER PER HR Lbs.	DRY STM P. HR. Lbs.	REC. DRAIN P HR Lbs.	STM. TO AUX'S Lbs.	INJECT WATER TEMP. °F.	DISCH. WATER TEMP. °F.	I.H.P. H.P.	I.H.P. L.P.	I.H.P. TOTAL H.P.	DRY STM. p.K.W.H. Lbs.	DRY STM. per I.H.P.H. Lbs.	B.T.U. ADDED PER POUND WATER	B.T.U. REJ. PER POUND WATER	EFF. RANKINE %	EFF. THERMAL %	EFF_T / EFF_R %	B.T.U. DRAINS %	B.T.U. CONS'N & RADN LOSS %
25	3100	180.1	388.3	9.7	9.13	28.81	100.55	56040	56349	2389	1517	36.8	55.7	2173	2306	4479	18.18	12.58	1205	840	30.3	15.7	51.7	0.9	71.4
22	4008	176.7	383.9	5.7	16.67	27.93	100.32	68190	68407	4882	1866	38.4	58.3	2699	2815	5514	17.07	12.42	1202	865	28.0	16.7	59.6	1.3	70.0
24	4577	174.4	387.8	10.6	21.7	28.00	100.58	85369	85865	5273	2949	36.8	65.3	3264	4076	7341	17.25	11.70	1204	866	28.1	16.5	58.1	1.2	70.3
21	5984	173.9	387.5	10.5	25.9	28.00	100.60	103896	104519	6031	1693	37.3	69.5	3717	4714	8431	17.47	12.40	1204	866	27.1	16.3	58.2	1.1	70.6
23	6772	173.3	385.5	8.7	30.0	27.71	100.50	124702	125326	6060	2091	37.7	70.4	4346	5732	10078	18.51	12.37	1203	875	28.3	15.4	56.4	1.0	71.6
27	4932	173.9	387.3	10.5	10.44	28.11	100.60	89525	90062	5367	1826	37.76	72.66	3770	5184	8954	18.04	12.95	1205	865	28.2	15.8	56.0	1.0	71.2
26	4970	173.2	386.1	9.4	15.21	28.00	100.53	86267	86724	5518	1728	35.5	64.1	3443	3452	6895	17.45	12.58	1204	866	28.1	16.3	58.1	1.2	70.5
29	4976	174.9	386.9	9.4	20.41	28.00	100.53	85557	86010	5234	3034	38.1	75.0	3124	3722	6846	17.29	12.59	1205	866	28.1	16.4	58.6	1.2	70.4
28	4970	174.3	388.8	11.7	25.35	28.02	100.66	85933	86501	4890	663	36.7	72.6	2982	4127	7109	17.42	12.17	1206	868	28.2	16.4	58.1	1.1	70.5
31	3968	177.7	387.5	8.9	32.62	—	100.81	109317	109874	5548				2625	2372	4997	27.55	21.99	1205	1017	15.6	10.3	66.2	1.1	70.6
32	4980	176.2	386.7	8.7	36.93	—	100.50	128056	128635	6352				2835	3333	6168	25.84	20.88	1204	1017	15.5	11.0	71.1	1.0	76.0
30	4961	148.2	372.0	7.0	21.06	28.04	100.40	88041	88394	5082	1234	37.40	72.4	3068	4019	7087	17.82	12.48	1200	875	27.1	16.0	58.7	1.1	70.9

Tests 31 and 32 were noncondensing. The B.t.u. required to make up mechanical and electrical losses is taken uniformly at 12 per cent.

TABLE 2. TEST OF COMBINED UNIT. CONDITIONS OF VACUUM AND QUALITY OF STEAM ENTERING TURBINE NEARLY STANDARD.

		Loads			Pressures								Temperatures					
													Calorimeter					
No. Test	Duration Hours	Total Units K.W.	Engine K.W.	Turbine K W	Mn. Steam Abs. Lb. per Sq. inch	Receivers Abs. Lb. per Sq. inch	L.P. Separator Abs Lb. per Sq. inch	Vacuum Inches Hg.	Vacuum Absolute Manom. Inches Hg. Abs.	Vacuum Abs Lb. Abs.	Barometer Inches Hg	Std Vacuum 28.92 Bar. Inches Hg	Steam Temp °F	Quality Percent	Turbine Bowl °F	Condenser °F	Hot Well Water °F	Circ Water Injection °F	Circ Water Discharge °F
38	5	16172	8384	7784	197.0	64.2	20.60	29.30	1.50	.74	30.63	28.42	380.6	99.5	228.5	90.90	71.20	37.66	57.28
39	5	13485	7798	5895	203.8	64.5	16.50	29.10	1.58	78	30.59	28.34	383.4	97.9	217.0	94.60	76.23	39.85	62.51
40	5	13038	7314	5711	196.1	63.8	16.20	29.46	1.22	.60	30.61	28.72	380.2	99.2	216.1	84.45	70.97	32.03	51.84
41	5	12284	6938	5348	200.2	64.5	16.10	29.32	1.31	.64	30.57	28.69	381.9	98.9	216.3	87.17	73.41	33.95	56.76
42	5	11252	6248	4938	197.0	64.0	16.24	29.41	1.32	.65	30.65	28.60	380.6	98.7	216.9	87.18	75.25	31.82	56.67
43	5	10476	5824	4602	198.0	63.8	16.20	29.23	1.46	.72	30.58	28.46	381.0	98.5	216.3	89.32	80.17	32.75	57.14
44	5	9408	4940	4426	198.8	63.8	16.10	29.47	.93	.46	30.31	28.99	381.3	98.7	216.1	73.87	59.42	31.63	41.98
45	1¾	9712	5916	3709	198.2	64.3	10.50	28.96	1.22	.60	30.21	28.70	381.1	98.7	196.7	86.72	66.20	32.22	43.97
46	½	12700	7180	5640	198.5	62.6	12.96	29.45	1.03	.51	30.32	28.89	381.2	98.8	208.0	77.20	63.70	40.20	53.10
47	½	11940	7060	4780	195.3	62.6	12.35	29.72	1.03	.51	30.32	28.89	379.9	99.1	204.0	80.00	63.00	36.00	46.85
48	3	9306	5865	3323	196.3	46.3	9.65	29.13	1.20	.59	30.33	28.72	380.3	98.6	189.4	84.86	60.58	32.90	42.06
49	1	10940	6640	4300	194.9	49.3	11.65	29.19	1.13	.56	30.32	28.79	379.7	98.9	201.0	83.50	62.60	31.38	53.86
50	4	15498	8169	7260	192.0	59.0	17.80	29.23	1.13	.56	30.32	28.79	378.5	99.4	221.0	82.23	65.69	31.51	50.08
51	3	11240	6753	4376	194.0	55.0	11.50	29.25	1.19	.58	30.38	28.73	379.4	98.6	199.8	83.16	65.18	37.50	43.10
52	3	7200	4743	2400	196.5	41.5	7.97	29.07	1.29	63	30.29	28.63	380.4	98.4	180.8	85.70	58.15	31.47	39.81
53	3	11927	7070	4834	199.0	52.9	12.75	29.10	1.25	.61	30.26	28.67	381.4	98.6	204.6	83.65	65.65	31.46	45.37
54	3	14173	7820	6283	193.4	55.7	15.18	29.31	.93	.46	30.03	28.99	379.1	98.9	213.3	81.20	57.26	33.54	47.77
55	3	8347	5403	2910	197.4	43.0	8.21	2890	1.15	.57	29.97	28.77	380.8	98.6	183.8	81.00	58.64	33.08	41.30
56	3	13033	7457	5550	197.2	54.3	14.09	2901	1.01	50	29.90	28.91	380.7	98.7	207.6	74.70	60.72	33.40	50.10
57	3	14580	7960	6583	199.7	59.6	15.57	28.85	85	.42	29.49	29.07	379.2	99.0	215.5	67.41	53.2	33.28	47.60
58	3	6673	4420	2213	197.7	40.1	7.08	2848	98	.48	29.48	28.94	380.9	99.0	176.3	78.20	53.85	33.18	39.46
59	3	10007	6194	3804	199.1	47.3	10.35	2855	94	.46	29.50	28.98	381.5	98.2	194.1	78.30	59.12	33.40	43.66
60	3	11820	6923	4860	195.1	51.6	12.10	2896	87	.43	29.79	29.05	379.8	99.0	202.4	74.04	59.60	33.25	46.00
61	3	11480	6587	4893	196.8	51.4	12.34	28.88	1.00	.49	29.79	28.92	380.5	99.1	203.2	77.18	61.74	33.06	47.23
62	3	15860	8440	7410	195.0	63.4	17.84	2873	1.19	58	29.79	28.73	379.7	99.0	221.8	82.42	62.79	33.64	56.00

		Indicated Horsepower				B.t.u. Distribution: Unit is 1,000,000 B.t.u.													
No. Test	Duration Hours	Average High Pres. I.H.P.	Average Low Pres. I.H.P.	Total I.H.P.	Factor I.H.P / K.W	Supplied To Unit B.t.u.	Supplied To Turbine Only B.t.u.	Supplied To Turbine Only. Percent	Engine K.W Output B.t.u.	Engine K.W. Output Percent	Turbine K.W. Output B.t.u.	Turbine K.W. Output Percent	Total K.W. Output B.t.u	Total K.W. Output Percent	To Condenser B.t.c	To Condenser Percent	To Hot Well B.t.u.	To Hot Well Percent	Lost by Radia. etc. B.t.c.	Lost by Radia. etc. Percent
38	5	5640	6117	11757	1.404	292.0	252.5	86.5	28.61	9.8	26.58	9.1	55.19	18.9	216.6	74.2	9.31	3.2	10.89	3.7
39	5	5104	5847	10951	1.404	232.6	196.6	84.6	26.36	11.3	19.68	8.6	46.27	19.9	168.4	72.4	8.28	3.6	9.64	4.1
40	5	4931	5650	10581	1.447	218.0	182.5	83.7	24.97	11.5	19.49	8.9	44.46	20.4	156.4	71.7	6.65	3.1	10.53	4.8
41	5	4800	5306	10106	1.457	204.7	171.8	83.9	23.67	11.6	18.25	9.9	41.92	20.5	146.9	71.7	6.64	3.2	9.23	4.5
42	5	4250	4330	8580	1.374	187.7	159.5	85.0	21.35	11.4	16.95	9.0	38.37	20.5	136.2	72.5	6.36	3.4	6.85	3.7
43	5	4227	4280	8507	1.460	174.5	149.8	85.9	19.93	11.4	15.76	9.0	35.68	20.5	127.3	73.0	6.69	3.8	4.77	2.7
44	5	3771	3490	7261	1.470	155.8	131.9	84.6	16.87	10.8	15.12	9.7	32.09	20.6	113.4	72.7	3.36	2.2	7.03	4.5
45	1¾	3819	4367	8186	1.385															
46	½	4994	6313	11307	1.575															
47	½	4675	5736	10411	1.475															
48	3	4129	4321	8450	1.441	150.5	122.3	81.3	20.14	13.4	11.46	7.6	31.61	21.0	107.6	71.5	3.27	2.2	8.06	5.4
49	1	5039	4545	9584	1.444															
50	4	5784	5825	11609	1.421	264.2	224.2	84.8	27.95	10.6	24.85	9.4	52.56	19.9	192.5	72.8	6.83	2.6	12.05	4.6
51	3	4585	5244	9829	1.456	178.0	146.0	81.8	23.16	13.0	15.05	8.4	37.85	21.3	126.5	70.9	4.43	2.5	8.84	5.0
52	3	3662	3478	7140	1.505	118.4	96.41	81.4	16.25	13.7	8.26	7.0	24.37	20.6	85.8	72.5	2.33	2.0	5.74	4.8
53	3	4995	4897	9892	1.400	191.8	157.8	82.3	24.16	12.6	16.53	8.6	40.66	21.2	136.4	71.2	4.84	2.5	9.84	5.1
54	3	5430	5370	10800	1.400	232.4	197.8	83.4	26.76	11.3	21.53	9.1	48.29	20.4	171.8	72.4	4.46	1.9	7.84	3.3
55	3	3907	3792	7699	1.425	133.8	109.55	81.9	18.48	13.8	9.97	7.5	28.45	21.3	97.9	73.2	2.64	2.0	5.77	4.3
56	3	5115	5120	10235	1.373	210.0	175.5	83.6	25.46	12.1	18.97	9.0	44.43	21.2	151.9	72.3	4.54	2.2	9.04	4.3
57	3	5376	5673	11049	1.388	240.7	205.4	85.4	27.20	11.3	22.51	9.4	49.74	20.7	179.0	74.4	3.87	1.6	8.10	3.4
58	3	3282	3170	6452	1.460	110.4	89.25	80.9	15.13	13.7	7.59	6.9	22.73	20.6	79.8	72.4	1.78	1.6	6.02	5.5
59	3	4452	4294	8746	1.413	160.0	133.6	83.2	21.13	13.2	12.99	8.1	34.12	21.3	116.7	72.9	3.28	2.1	5.87	3.7
60	3	5108	4796	9904	1.431	189.8	158.9	83.7	23.67	12.5	16.62	8.8	40.29	21.2	138.4	72.9	3.92	2.1	7.23	3.8
61	3	4728	4594	9322	1.414	191.8	161.5	84.2	22.47	11.7	16.70	8.7	39.17	20.4	140.5	73.3	4.28	2.2	7.83	4.1
62	3	5750	6538	12288	1.456	269.2	232.2	86.3	28.82	10.7	25.31	9.4	54.11	20.1	200.5	74.5	6.36	2.4	8.18	3.0

TABLE 2. TEST OF COMBINED UNIT (CONTINUED).

		Water Rates					Efficiencies									Heat to Condenser		
							Rankine Efficiencies			Thermal Efficiencies Referred to Rankine			Thermal Efficiencies Recover H.W. Water					
No. Test	Duration Hours	Actual Unit Lb per K.w.Hour	Actual Engine Lb. per K.w.Hour	Actual Turbine Lb per K.w.Hour	Corr Unit Moist only Lb. per K.w.Hour	Corr Unit Total Corr. Lb. per K.w.Hour	Engine Percent	Turbine Percent	Unit Percent	Engine Percent	Turbine Percent	Unit Percent	Engine Percent	Turbine Percent	Unit Percent	Ratio c.w./st.	B.t.u Per Sq.in. Sec.	B.t.u. Per Sq.in sec. Per degree Rise
38	5	15.07	29.54	27.51	14.40	14.10	16.7	18.2	30.1	70.3	60.0	65.0	11.7	10.9	19.5	53.5	2.58	.0594
39	5	14.32	24.76	28.38	13.48	13.10	16.8	16.8	29.1	81.5	63.5	70.5	13.7	10.7	20.5	48.2	1.99	.0459
40	5	13.92	24.78	27.35	13.44	13.42	17.8	18.4	30.8	76.9	60.0	68.5	13.7	11.0	21.1	52.9	1.86	.0437
41	5	13.88	24.57	27.51	13.39	13.28	17.6	17.7	30.4	78.5	62.3	69.7	13.8	11.0	21.2	46.4	1.77	.0428
42	5	13.87	24.99	27.72	13.54	13.42	17.4	17.8	30.3	76.4	61.8	70.1	13.6	11.0	21.2	42.7	1.65	.0384
43	5	13.85	24.90	27.91	13.47	13.21	17.3	17.7	30.2	78.9	60.5	70.7	13.6	11.4	21.4	44.2	1.53	.0345
44	5	13.75	26.19	25.53	13.32	13.59	17.6	18.8	29.4	73.2	62.5	71.8	12.9	11.7	21.1	107.7	1.37	.0369
45	1¾	13.72	22.53	30.59	13.49	13.45												
46	½	13.99	24.75	27.38	13.62	13.77												
47	½	13.30	22.49	28.45	13.15	13.31												
48	3	13.44	21.34	31.84	13.25	13.25	20.5	15.6	30.5	74.9	61.2	71.0	15.4	9.5	21.7	118.	1.26	.0266
49	1	13.69	22.40	29.50	13.39	13.46												
50	4	14.22	26.99	26.55	13.96	14.03												
51	3	13.19	21.95	28.89	13.04	13.04	19.7	16.4	30.8	76.7	53.6	72.0	15.1	10.5	22.2	150.	1.28	.0298
52	3	13.67	20.75	35.04	13.52	13.43												
53	3	13.38	22.57	28.22	13.13	13.08												
54	3	13.66	24.75	27.22	13.54	13.81	18.2	18.7	31.2	74.5	59.1	68.1	13.6	11.1	21.2	77.1	2.08	.0512
55	3	13.34	20.60	32.85	13.23	13.28	21.2	17.5	30.5	74.6	52.6	71.5	15.8	9.2	21.8	112.	0.92	.0210
56	3	13.40	23.43	27.72	13.28	13.47	18.2	18.4	31.0	78.5	59.4	69.0	14.2	10.9	21.7	63.4	1.87	.0566
57	3	13.75	25.19	26.95	13.65	14.00	18.0	19.5	32.2	74.0	57.0	65.4	13.6	11.1	21.0	77.5	2.16	.0800
58	3	13.76	20.78	35.27	13.65	13.87	21.3	14.6	31.4	73.2	59.0	67.0	15.6	8.6	21.0	153.	2.55	.0608
59	3	13.30	21.48	30.38	13.13	13.39	19.5	16.7	31.3	78.5	60.0	69.8	15.3	10.0	21.8	108.	1.41	.0336
60	3	13.38	22.84	28.41	13.28	13.61	19.5	20.2	32.2	74.8	52.9	67.6	14.5	10.7	21.8	82.9	1.67	.0485
61	3	13.92	24.45	24.22	13.75	13.95	19.6	17.6	31.4	69.8	60.4	66.9	13.7	10.7	21.0	108.	2.40	.0885
62	3	14.14	26.58	26.56	13.99	13.99	17.2	18.7	30.0	74.0	59.4	68.9	12.7	11.1	20.7	49.	2.52	.0670

starting in this way, the induction generator acts as a motor until sufficient steam passes through the engine to carry the turbine above synchronism, when it immediately becomes a generator and picks up the load. Three of these low-pressure turbines have been installed.

The paper is accompanied by a mass of tables and curves showing the results of tests upon the engine before the addition of the turbine, from which Table 1 herewith has been made up, calculations and data supplied by the turbine manufacturers of the turbine to determine probable results and tests of the combined units, of which we reproduce in Table 2 the results of the latest made with the conditions of vacuum and quality of steam nearly standard. It is rarely that such a mass of data as this paper comprises is released for general study and public criticism and it is certain that an analysis of it will bring out some interesting discussion. All the data are available in the *Journal* and *Proceedings* of the society. A description of the unit was published in POWER for December 14, 1909.

The net results obtained by the installation of the low-pressure turbine unit may be summarized as follows:

A saving of approximately 85 per cent. of the condensed steam for return to the boilers.

An increase of 100 per cent. in maximum capacity of plant.

An increase of 146 per cent. in economic capacity of plant.

An average improvement in economy of 13 per cent. over the best high-pressure turbine results.

An average improvement in economy of 25 per cent. (between the limits of 7000 and 15,000 kilowatts) over the results obtained by the engine units alone.

An average unit thermal efficiency between the limits of 6500 and 15,500 kilowatts of 20.6 per cent.

Remarkable Performance of Small Engine

A type of engine which is much used in Europe, but which is made in the United States only in the cheaper and simpler forms, is the semi-portable, where the engine is mounted directly upon the boiler and even has a condenser attached.

The Engineer of London publishes a report of a test of a 50-horsepower unit of this sort which ran on 1.21 pounds of Welsh coal per brake horsepower-hour. The pressure of the steam at the boiler side of the stop valve was 192 pounds absolute, and the temperature 536 degrees Fahrenheit. The absolute pressure at the exit from the engine was 2.87 pounds per square inch. The indicated horsepower (French), 58.2; brake horsepower, 55.4; mechanical efficiency, 95.5. The heat supplied per minute per indicated horsepower (French) but in B.t.u., was 198.2, giving a thermal efficiency of 21.3 per cent., the heat equivalent of the indicated French horsepower being 2437 B.t.u. as against 2545 for the horsepower in British units. The amount of steam used per indicated horsepower-hour was 10.12, and per brake horsepower-hour 10.66 pounds; certainly a very moderate consumption for a steam engine of this capacity.

Power and The Engineer
Devoted to the Generation and Transmission of Power

What Do You Know about Draft?

We have often called attention to the fact that the engineer finds opportunities for making economies and saving money in the boiler room that he never finds in the engine room. We have commented on the folly of adjusting the engine valves in an effort to get the indicator diagram just right and in this way to save a very small amount of steam, while in the boiler room, amidst less attractive surroundings, mistakes are overlooked which, if corrected, would show handsome savings.

In the last analysis, the engineer's job is to make power cheaply. He is given for this purpose certain tools with which to work: boilers, pumps and heaters with which to make the steam, and engines and generators in which to use the steam and develop the power. Certainly he is as much responsible to his employers for the money he spends in the boiler room as for the money he spends in the engine room. A dollar saved in the coal bill should be as attractive to the president of the company as a dollar saved in any other department. Although most of us will admit that these things are true, we find in the big majority of power plants throughout the country that the engineer's chief attention is given to the engine room and that he sadly neglects what is really the most important part of his plant.

In order that the attention of our readers may be brought to this matter, it seems desirable to speak in these columns of a few particular things in the boiler room that the engineer should watch and follow up continually. This week we will mention the subject of draft as being one of the most important in the field of steam engineering. How many engineers can talk intelligently about draft? Why do we need draft in a boiler furnace and what causes the draft? How is it measured and is it a thing that the carelessness or inattention of the engineer can affect?

A short time ago in one of our large cities, the civil service department of the local municipal government held an examination for certain engineering positions where the applicants were expected to have all had some years of practical experience in charge of boiler plants. One of the questions was: "How high would you build a smokestack for a boiler plant having two hand-fired seventy-two-inch by eighteen-foot horizontal tubular boilers with a stack sitting directly on top of the boiler settings? What would be the internal area of the stack? What draft in inches of water would you have: first, at the base of the stack; second, at the front end of the tubes; third, in the furnace?

The answers to this question were a disgrace to the men, all claiming to be engineers, who took the examination. The hight of the chimney varied from thirty feet to two hundred feet. The diameter varied from twelve inches to six feet; but the most ridiculous answers were given to the last part of the question. One man said there would be fifteen inches of draft at the base of the stack, twenty-four inches of draft at the front end of the tubes and thirty-six inches in the furnace. Another man said that there would be three inches of draft at the base of the stack, two inches at the front end of the tubes and three inches in the furnace. Only two or three men out of a total of forty-five seemed to have any intelligent idea of the proportions of smokestacks or of the proper draft necessary for burning coal. The men who took this examination were woefully lacking in an ability to measure draft and to understand what the measurements meant.

Can it be that the use of the draft gage is so little understood among engineers? In some boiler houses where great attention has been given to these matters, draft gages are found on every boiler recording the draft over the fire. The dampers are regulated so as to keep the draft over the fire correct for the amount of steam desired from the boiler. These draft gages are not merely ornamental. They tell to the engineer in charge the condition of his fires from one cleaning to the next. They tell him how much coal he can expect to burn per square foot of grate surface and therefore tell him how much steam he can get out of the boiler because, other things being equal, the capacity of the boiler is entirely a function of the amount of coal that can be burned in its furnace. In our experience we have often known of power plants where boilers were overcrowded and the plant needed more power. The owners had been considering the installation of other boilers; the engineer had informed his superiors that they must have more steam and that the only way to get it was to install more boiler capacity. Upon a careful examination of the boiler room, the draft in the furnace was found to be insufficient. The

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boilers were not particularly overloaded but the engineer was unable to burn any more coal and therefore could not make more steam. The stack was apparently high enough; the boiler setting was clean and the breeching connections were clean but the limits of steam making had apparently been reached. On a closer examination, however, it developed that in the breeching there were two sharp right-angle bends, resulting in peculiar turns of the gases in their effort to escape to the stack. This tortuous twist in the breeching was apparently thought necessary when it was built to avoid a building column long since removed, yet the kink had stayed in the breeching for years and had cost the owner thousands of dollars in his coal bill, because with the insufficient draft the fires had not been supplied with enough air and the combustion had not been complete. Yet the engineer in charge of this plant had never noticed this thing; he had never used his draft gage; he did not know how much loss in draft there was between the base of the stack and the furnace. He had merely burned all the coal he could and thought he had reached the capacity of his plant. A simple change in the breeching, involving only a few hours of boilermaker's work, would put the plant in shape to develop considerably more power and supply the needs of the plant. Probably throughout the country today there are thousands of boiler plants where the draft is insufficient and which could be easily remedied by straightening out a breeching, making a larger connection into the base of the stack, rearranging the dampers so that they do not interfere with the draft when open, changing the baffling slightly in the boiler itself, etc. What is needed is, that the engineer get into his fire room and study every detail of his boiler equipment with the same care and thoroughness that he has in the past devoted to his engine room.

Turbines vs. Reciprocating Engines for Textile Mills

In a paper read before the Manchester (England) Association of Engineers and reported in a recent issue of the *Mechanical Engineer*, it was pointed out that little use had been made of the turbine in Great Britain for the driving of cotton mills. In Lancashire and Yorkshire steam users have, during the late boom in mill building, adhered almost exclusively to the reciprocating engine. As this policy has been adopted mainly as the result of the advice of independent engineers with a wide experience in power application, it may be reasonably assumed that, for the conditions which usually prevail, turbine driving does not afford sufficient advantages to warrant the displacement of the reciprocating engine. From a mechanical point of view nothing can be simpler than the rope driving the main line shafts of the several floors of a mill direct from the flywheel drum. With the necessarily high speed of rotation of turbines, however, reduction gear is inevitable, and practically a turbine installation involves electrical power distribution with a central generator and motors for each of the line shafts.

For plants of less than 500 horsepower the turbine alone has no chance of competing with a reciprocating engine because its cost is greater; but in large units, say 1000 horsepower and upward, such as are needed in a modern textile mill, the relative price gives a decided advantage to the turbine; and it is this consideration alone which enables the turbo-generator to enter into a possible competition with a reciprocating engine.

In the paper under notice the author endeavors to make a comparison between the running cost of a mill requiring 1600 horsepower when driven by a triple-expansion inverted vertical engine, with rope drives, and when driven with a turbo-alternator, the current from which is used to operate motors driving the line shafts. The type of engine selected is more expensive, probably to the extent of 15 per cent., than the horizontal cross-compound type which is so largely used and so admirably meets mill-driving requirements. He finds in the case of the reciprocating engine, with boiler economizers and auxiliary plant, the cost to be £18,200 and in the case of the turbo-alternator £19,600. The editor of the *Mechanical Engineer* is inclined to criticize the author's estimate of the running cost of the two systems. The reciprocating engine is debited with an annual cost of £187 for attendance as against £125 for the turbine, and he argues that while the turbo-generator would require less attention in the engine house, a skilled man would be needed on the other hand to superintend the electrical plant and little or no saving would be effected in this direction. Oil, stores, upkeep and repairs are together put down as £200 for the reciprocator, as against £105 for the turbine. The author estimates the annual cost of upkeep and repairs as £100 for the engine and £60 for the turbine. "This," says the editor of the *Engineer*, "is a matter on which the engine-insurance companies could shed an interesting light were they so disposed, and particulars of turbine breakdowns were fully available. In their absence it is sufficient to note that the rates for turbine insurance are very much higher than for modern mill engines, and it is, therefore, reasonable to conclude that the insurance companies find the upkeep of turbines is higher than reciprocating engines and not lower as the author states."

The author's final figures make the charges, including interest and depreciation, £2 9s. 4d. per indicated horsepower per annum for the mechanical drive, and £2 9s. 10d. for the electrical drive.

Taking the author at his own figures, there is no advantage in cost for the turbine and the electrical drive. A committee appointed by the Bradford Engineering Society to investigate the question found that there was practically no difference in cyclical variation between mechanical and electrical transmission, and that power was conveyed with less loss by mechanical than by electrical transmission. Electrical transmission possesses advantages when the power has to be distributed through various buildings, or where the arrangement of machinery is irregular, and it is this consideration which has determined the adoption of electric driving in several of the instances referred to in the paper. But up to the present the evidence is distinctly in favor of the reciprocating engine and rope drive for new mills.

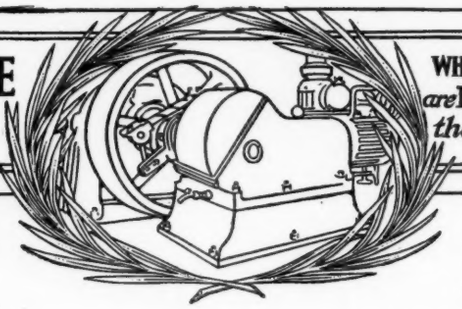
Among the books not classed as fiction, of the three most in demand at the New York City Public Library during the week ending February 8, was Merriman's "Roofs and Bridges." This is a forceful illustration of the trend of the times.

Alaska is said to have a total area of coal-bearing rock amounting to 900 square miles. The coal is excellent in quality, varying from an anthracite with 84 per cent. of fixed carbon to a semi-bituminous of 74 per cent. fixed carbon. Most of it is now in the hands of the people and it behooves the power users in whose fuel supply it is likely to become an important factor, not to let it get away.

Last January a bill authorizing an appeal to the Superior Court from the regulations of the Board of Boiler Rules and giving to such court power to revoke or modify these regulations was introduced into the Massachusetts Legislature. A public hearing was held after which the Joint Judiciary gave permission for the withdrawal of the bill from both the Senate and House of Representatives, which was promptly accepted.

In starting up a steam turbine, a condition exists somewhat analogous to the starting of an electric motor. In the motor the current finds a free path from the higher to the lower potential level until a counterelectromotive force is built up by the rotation of the armature. In the turbine the steam finds a free path from the boiler to the condenser level, and it is only after the rotor is in motion and the pressures in it established that this condition ceases. Care must be exercised to avoid excessive initial flow in both cases.

NEW POWER HOUSE EQUIPMENT



WHAT *the* INVENTOR *and the* MANUFACTURER *are* DOING *to* SAVE TIME *and* MONEY *in the* ENGINE ROOM *and* POWER HOUSE

Wisconsin High Speed Corliss Engines

In perfecting their Corliss engine so that it might run at a speed of 175 revolutions per minute with a minimum of friction, wear and noise, the Wisconsin Engine Company, of Corliss, Wis., has made some notable improvements in the cylinder, valves and valve gear.

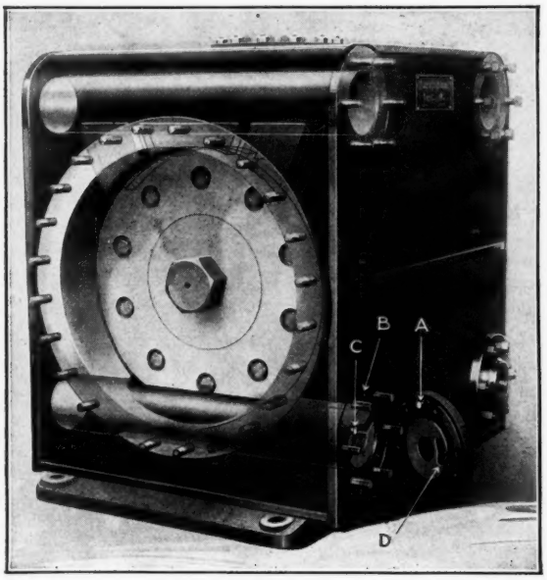


FIG. 1. CYLINDER OF WISCONSIN CORLISS

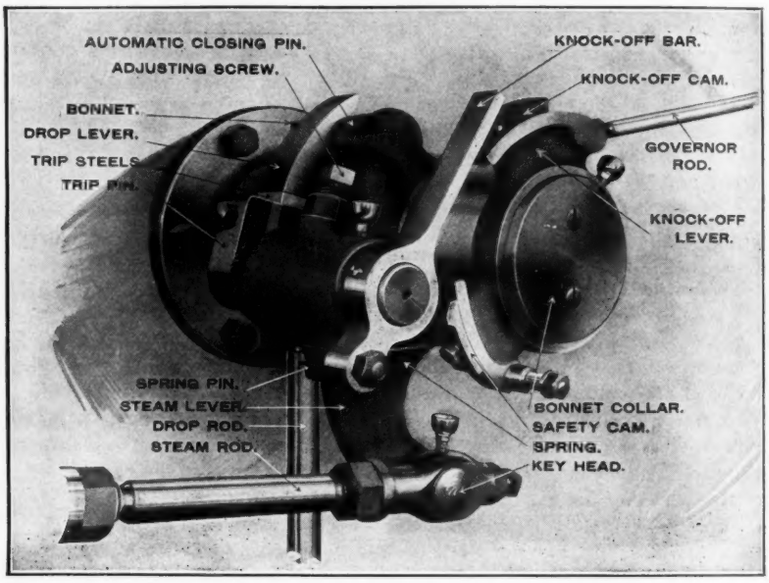


FIG. 2. VALVE GEAR

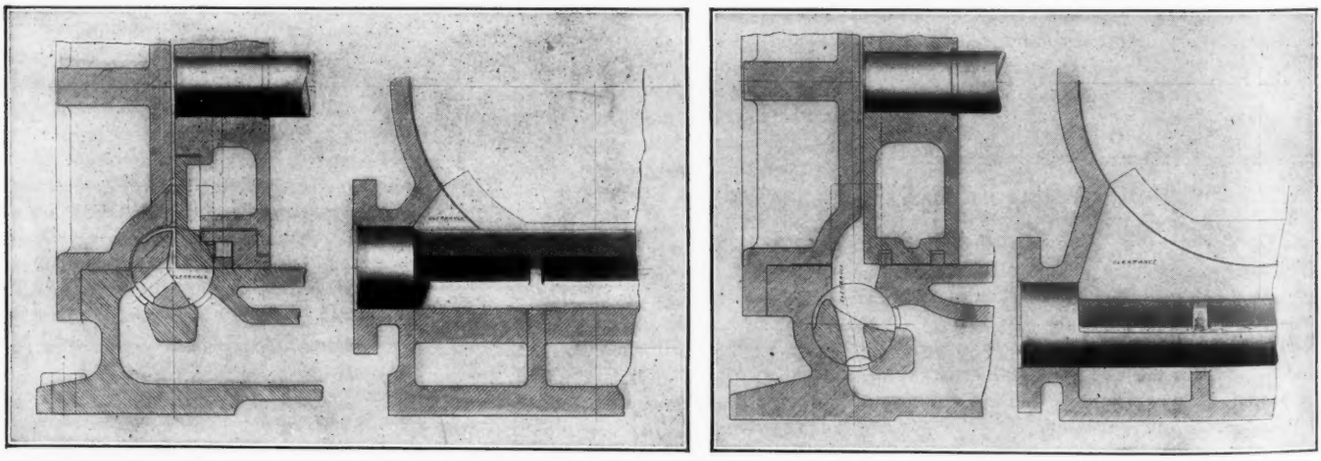


FIG. 3. ARRANGEMENT OF VALVE TO REDUCE CLEARANCE AS COMPARED TO USUAL POSITION

In the operation of an engine, cylinder condensation, clearance, wire drawing and leakage are responsible for a large percentage of the loss encountered. Condensation may be lessened to a marked degree by increasing the velocity of the steam through the cylinder. This means a high piston speed and large ports in the valves. Increasing the size of the exhaust ports, however, enlarges the clearance space, and as this feature is of great importance in securing a high degree of steam economy, the exhaust valves in the present design have been raised until their center line is level with the bottom of the cylinder bore, as shown in Fig. 3. Ordinarily, the exhaust valves are located as far below the center line of the cylinder as the steam valves are above it. The effect of raising the exhaust valves is apparent in Fig. 3, which shows the ordinary and new locations.

In addition to high piston speed, large port areas, which reduce wire drawing of the entering steam and throttling of the exhaust steam, and low clearance, the efficiency of the engine is further aided by the almost entire absence of valve leakage. From the illustrations it may be noted that although the exhaust

As about 70 per cent. of the total clearance of the Corliss engine is in the exhaust valve and its chamber, it may readily be seen how greatly the clearance has been reduced in the present case. Even with the larger port openings it is said that the total clearance is but 50 to 60 per cent. of what it would be with the exhaust valves in their usual location.

valves are unusually close to the cylinder bore, no part of the valves at any time enters the space into which the piston travels. Should the valve gear be unhooked and worked by hand into an extreme position, a stop is provided so as to preclude accident from this remote cause. The back bonnets covering the exhaust valves shown in Fig. 1 are doweled, *A B*, as well as bolted to the cylinder, so that it is impossible to put them on in any but the correct position.

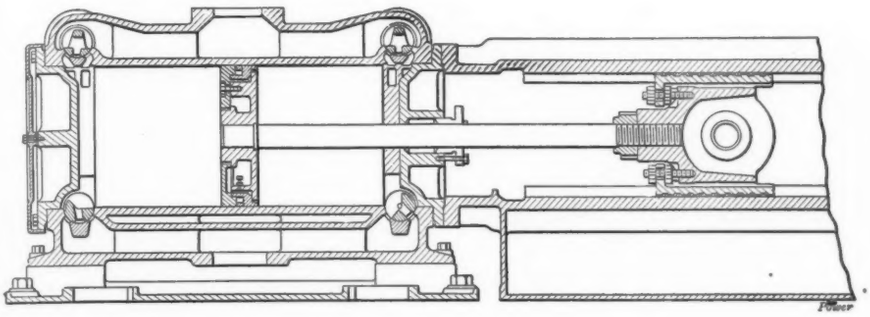


FIG. 4. LONGITUDINAL SECTION THROUGH CYLINDER

As a further insurance the valve is provided with a heavy steel pin *C* which works in a limiting slot *D* in the back bonnet. In Fig. 4 it is shown that the double ports in the cylinder are located equidistant from the vertical center line of the valves, so that they will automatically take up any slight wear and remain tight for an indefinite period.

For simple engines and the high-pressure cylinders of compound engines, the cylinders are designed for working steam pressures of 150 to 200 pounds, and the low-pressure cylinders are designed for pressures of 100 to 150 pounds.

The design of the valve gear for the engine under description is shown in Fig. 2. In this type of gear the drop lever is rigidly attached to the middle of the valve stem, and inside the bonnet opening, instead of being keyed to the extreme end of the stem, which affords the valve stem a supporting bearing on both sides of the actuating points instead of having it overhung; and as the steam valves are opened against the resistance of the dashpots, the leverage on the bonnets which must support the gear is reduced to one-half that of the other construction. Instead of merely being keyed to the valve stem, the drop lever is bored taper and a split taper sleeve fits around the stem and into the drop lever. The edges of the sleeve fit snugly against the key which fits in both the stem and lever, and on the end of the sleeve is a drive nut. When this nut is tightened up the sleeve is wedged immovably between the stem and lever and its edges fit on both sides of the key, thus locking all these parts together as though they were a solid forging, yet permitting their ready removal.

As the knock-off lever has but little strain placed upon it, it is located at the end of the bonnet and rides on a collar which shoulders against the steam lever and keeps it from touching the knock-off collar and interfering with the operation of the governor. The lap of the trip steels is controlled by the adjusting screw, and can be changed while the engine is running, so that if the edge of one of the steels becomes damaged, it can immediately be given a little more lap and a shutdown avoided. The spring is flat and its tension can be adjusted by turning the spring pin and clamping it with its nut. The dashpots have double vacuum chambers and are reported to be remarkably quick acting at any point of cutoff.

Other parts and mechanisms of the engine are much the same as in the older design of engine made by this company.

The Rapid Packing Tool

The accompanying illustration shows a useful packing tool designed and patented by Haden H. Bales, Ashcroft, B. C., Canada. The tool is a useful appliance for operating engineers who have to pack glands on engines, pumps, air compressors, or refrigerating machines. It will draw out old packing that is difficult to remove from the stuffing boxes, and in

PACKING EXTRACTING BIT

situations where a rigid packing tool cannot even be turned. The bit portion of the tool is designed to pierce hard packing easily and to grip it tenaciously. The bit is also made to screw out of the stock, so that it can be replaced when desired. The tool is made of steel carefully tempered and all bright parts are nickel plated.

Uehling Vacuum Recording Gage

Wherever indications of vacuum of great accuracy are required, the mercury column is usually resorted to. Recognizing this point, the Uehling Instrument Company, of Passaic, N. J., is putting on the market the vacuum recorder shown in the accompanying illustrations. Fig. 1 shows the face of the instrument and Fig. 2 a sectional elevation. The recorder consists essentially of a steel U-tube, one leg *A* of which is of sufficient size to contain a float and is fastened to the case containing clockwork for rotating a recording disk in the usual manner. The smaller leg *B*, which is made of drawn steel tubing, extends above the top of the case to which it is fastened and connects with the source of vacuum to be recorded. The pen is actuated by a steel float resting on the mercury column in the large leg. The cross-sectional areas of the two legs are so chosen that the movement of the pen covers the chart when the vacuum has caused the mercury to rise to the maximum hight in the steel tube. From the illustrations it is apparent that the recorder is of simple construction and should possess great accuracy and reliability.

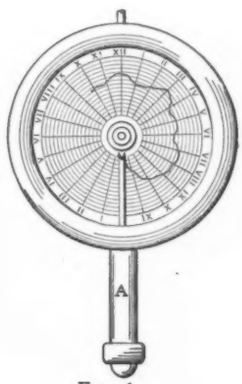


FIG. 1

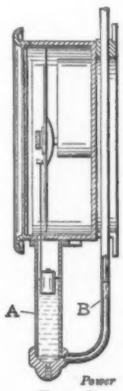


FIG. 2.

Consul Maxwell Blake, of Dunfermline, reports as follows concerning an independent movement in Scotland to aid the unemployed:

A very novel and interesting experiment has recently been inaugurated in this country by the formation of a conjoined labor exchange and unemployment society. Its proportions, however, are so far only of a local character, but the membership is already something over 300.

Those desiring admission into this guild are assessed a weekly sum equal to about eight cents and after four months' subscription are privileged to draw upon emergency unemployed benefits up to 40 cents per day. This sum, however, is not available to the same member for more than 48 days in any financial year.

The Fairbanks-Morse Gas Engine

A line of horizontal single-acting producer-gas engines in sizes up to 500 horsepower is being brought out by Fairbanks, Morse & Co., Chicago. The purpose of the design has been to provide a heavy-duty medium-speed engine, capable of meeting the most exacting demands both for reliability and durability, and to embody the best features of both European and American practice.

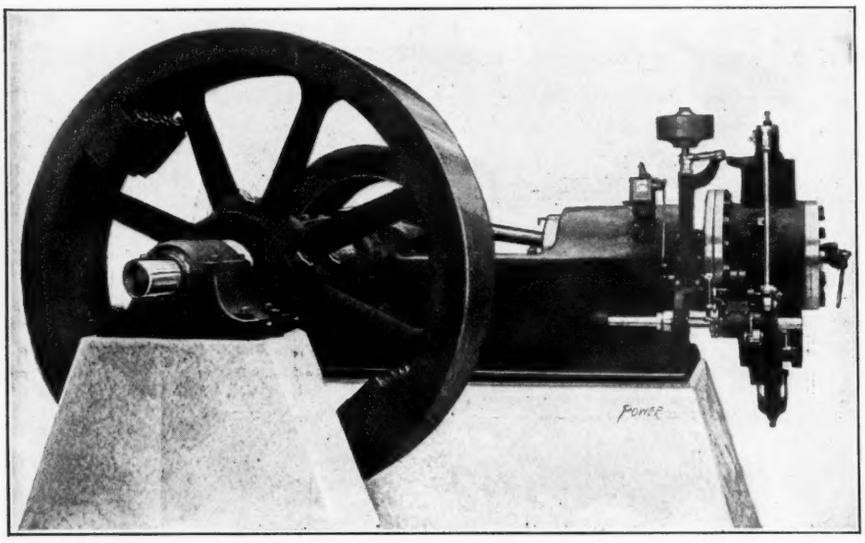


FIG. 1. FAIRBANKS-MORSE SINGLE-CYLINDER PRODUCER-GAS ENGINE

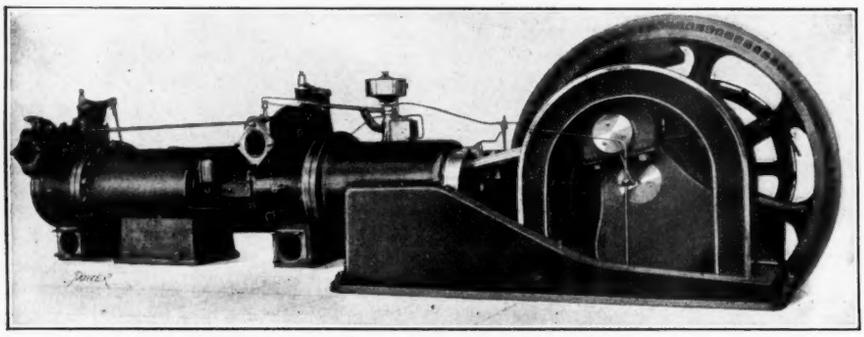


FIG. 2. FAIRBANKS-MORSE TANDEM PRODUCER-GAS ENGINE

Fig. 1 is an illustration of an 85 horsepower single-cylinder engine of this type, and Fig. 2 shows the same engine in tandem, making a 170-horsepower unit. Fig. 3 is a longitudinal section of a 250-horsepower tandem engine. These engines are built in single, tandem and twin-tandem types.

In the design of the frame special effort has been made to give the engine the requisite rigidity to withstand the heavy strains to which it is subjected, and by the adoption of the side-crank construction the frame carries but one main bearing, which is an advantage in the ease of alining the shaft. The crank shaft is solid, with a solid cast-steel crank disk forced on; the crank-pin is cast integral with the disk. The main bearings are equipped with removable shells, lined with babbitt, and adjustable. The crank-pin end of the connecting rod is of the marine type, and the wristpin bearing consists of a removable phosphor-bronze box in halves.

The cylinder-jacket wall is cast integral with the frame, and the cylinder barrel proper consists of an extension of the combustion chamber, bolted to a circular flange on the jacket barrel. This construction was adopted to enable the cylinder to expand freely without setting up strains in the jacket wall or entailing possibilitres of water leakage from the jacket to the interior of the cylinder. The shape of the combustion chamber is such as to avoid small pockets or recesses.

The ordinary trunk type of piston is used in the single-cylinder engine, while in the tandem engine the piston and rod are water cooled, using flexible joint connections similar to those found on representative European double-acting engines. The packing for the piston rod consists of a series of plain cast-iron rings in a water-cooled housing, and it can be removed without disturbing any other part.

The valves, igniters, governor, oil pump and air starter are operated by cams and eccentrics on the lay shaft, which is driven by a special gear located mid-way of the main bearing. This gear runs in oil and is made in halves so that it can be put on or removed without disturbing the crank shaft.

As shown in Fig. 3, the inlet and exhaust valves work in cages secured in pockets cast in the top and bottom walls of the combustion chamber. They are of such sizes as to secure a moderate velocity of gases through them, and the exhaust valve and cage are water cooled. Both valve cages may be removed without disturbing the piping.

Make-and-break ignition is used, the current being generated by oscillating-armature magnetos, one for each cylinder. The flyball governor acts upon a valve situated in close proximity to the inlet valve, and arranged to throttle the mixture without affecting its proportions. Special air and gas valves attached to

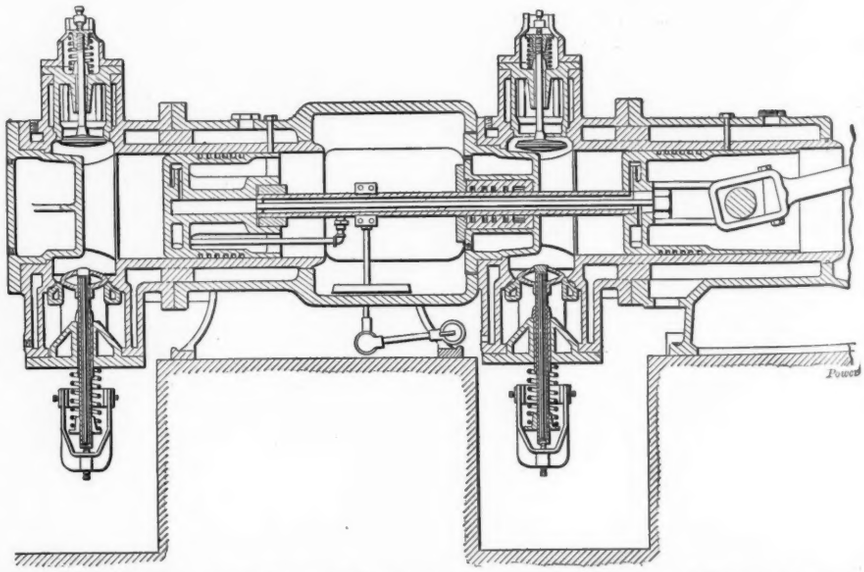


FIG. 3. LONGITUDINAL SECTION THROUGH THE CYLINDERS OF THE FAIRBANKS-MORSE ENGINE

the governor-valve casting provide for changing the proportions of air and gas, the mixture being effected just before reaching the governor valve.

The pistons and piston rods are lubricated by a force-feed oil pump and the other bearings are served by gravity feed from a central elevated tank. Compressed air is used for starting.

An Improved Slide Rule

To an average man the slide rule is a profound mystery. How a few passes on it can unearth the answer to a big problem in multiplication or division or give the area of a circle or the horsepower of an engine is beyond understanding. The standard slide rules are based on a principle which is simple enough if you know—there's the little joker, *if you know*. These standard rules are made and sold on the same if-you-know basis. If you know the principle of its operation, if you know all about logarithms, if you know a few other little things, you can understand the instructions for using the standard slide rule.

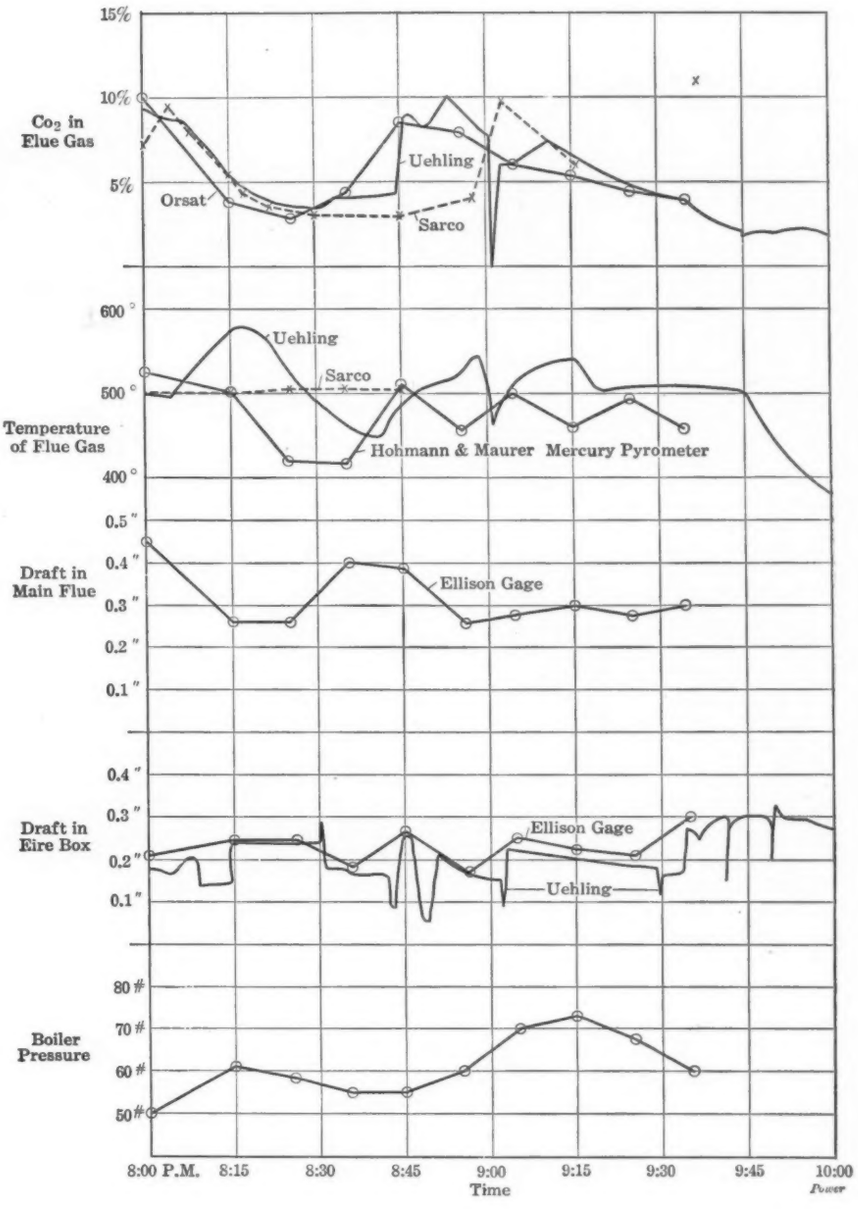
In the figure is shown a simplified slide rule. To understand how to use this rule, the only requirement is ability to read. The book of instructions, which is given with each rule, tells how to use it. Tells how in plain language; all theory, all complicated mathematics, all mysterious terms are carefully eliminated.

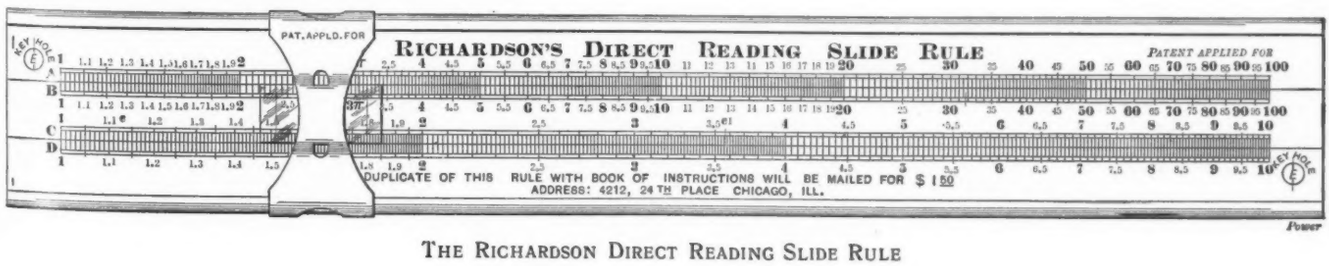
The maker of this rule calls it direct reading. It is more than that, it is quick acting and easy to understand and operate. Even a slide-rule adept would find this rule an improvement over the standard form. Its advantages arise from the system of key marks which makes adjustment extremely simple. It is not necessary to remember any ratios or constants, for the keys perform this function.

This direct-reading slide rule is manufactured by G. W. Richardson, 4212 Twenty-fourth place, Chicago. The back or stock is made of aluminum and has reinforcing ribs across it for strength and rigidity. The scales on the front are made of celluloid. The glass runner is held by stamped-steel guides and has a double index line. The rule and book of instructions now sells at $2.

Results of Combustion Test at Franklin Union, Boston

At the combustion symposium held at the Franklin Union, Boston, and reported in our issue of March 1, gas-analysis apparatus, pyrometers, etc., upon the stage were connected to the boilers immediately beneath and the readings were announced every fifteen minutes and plotted upon a blackboard in view of the audience. The above diagram is a reproduction of the plot received too late for use with our report of the meeting.

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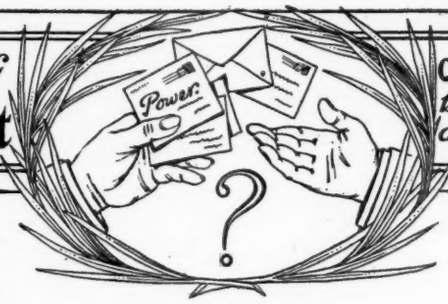
INQUIRIES of General Interest



QUESTIONS are NOT ANSWERED UNLESS they are ACCOMPANIED by the NAME and ADDRESS of the INQUIRER.

Operation of Bundy Return Trap

Will you please describe the Bundy return steam trap, with a sketch if possible, and state how it puts the water of condensation back into the boiler. I thought it was done by gravity, but it seems I am wrong.

P. M.

Bundy traps are made for several different kinds of service, the two most common of which are returning condensation from heating coils to the boiler and discharging condensation into tanks, other traps, or into the atmosphere. In general appearance both types are similar and the difference is in detail which is determined by the service for which the trap is to be used. Fig. 1 shows a diagrammatic sketch of the return trap. A pipe leading from the coils, tanks, or from another trap goes to the water space of the boiler past and on a level with

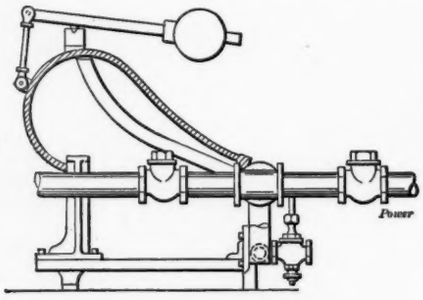


FIG. 1. RETURN TRAP

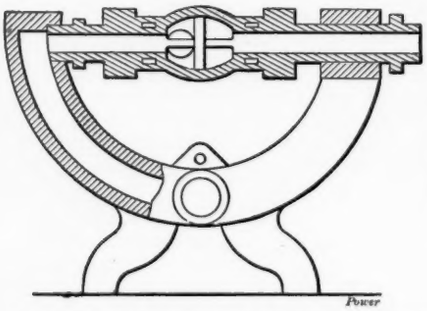


FIG. 2. HOLLOW TRUNNION AND SUPPORT

trunnions on which the receiving bowl tilts.

In this pipe are two check valves both opening toward the boiler, and between which a connection by means of a tee is made to the open-ended trunnion. To the hollow yoke, Fig. 2, which supports the trunnion, there is attached a globe valve which is opened and closed as the bowl tilts up and down. This valve is piped to the steam space of the boiler. Within the bowl is a curved pipe leading from the highest part of the interior to one of the hollow trunnions which communicates through the supporting yoke with the valve connected to the steam in the boiler.

While the bowl is empty, the counterweight holds the free end in its highest position and keeps the steam valve closed. The condensation coming along the pipe lifts the first check valve and enters the bowl until its weight overbalances the counterweight on the lever above the bowl, when the free end descends, opening the steam valve, admitting steam at boiler pressure to the bowl. This equalizes the pressure between the bowl and the boiler and the water lifting the check valve flows to the boiler by gravity.

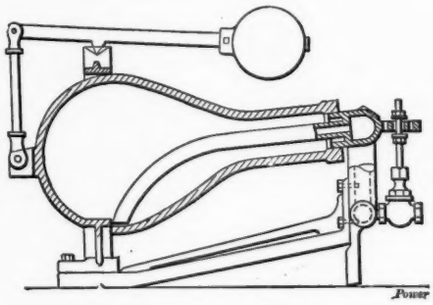


FIG. 3. SEPARATING TRAP

In the nonreturn trap, shown in Fig. 3, the pipe in the interior of the bowl is curved downward, the condensation enters the bowl through the trunnion as in the return trap, but is discharged through the valve attached to the yoke, which opens when the free end of the bowl descends.

Correcting Reversed Polarity

In restoring the polarity of a reversed direct-current dynamo by connecting it to the busbars with the brushes lifted from the commutator, is it necessary to run the armature of the machine at normal speed?

M. C. B.

No; it is not necessary to run the armature at all. The process of restoring the polarity is merely the magnetizing of the field magnet frame with current taken from the busbars, and the armature has nothing to do with it.

Fiela Connections of a Compounded Alternator

Does it make any difference which way the connections are made between the exciter and the main field winding of an alternator that has a compound field winding supplied through a rectifier?

M. C. B.

No. If the series winding is properly connected to the rectifier it will increase the field strength as the load increases, no matter which way the field is magnetized by the main winding. Reversing the main connections will reverse the polarity of the rectifier brushes and keep the series winding in agreement with the other one.

Wrought Iron ana Steel Cylinders

Is there any objection to wrought iron or steel as a material for gas-engine cylinders, other than the difficulty of shaping it?

J. L. D.

Wrought iron is not suitable because of its "grain" or fibrous structure. Cast steel has long been used for automobile engine cylinders and is now used by the Bethlehem Steel Company for large gas engines.

Point of Cutoff

How can I find the point of cutoff in a steam cylinder when the initial and terminal pressures are known?

G. E.

Adding 14.7 to both the initial and terminal pressures and dividing the initial by the terminal will give the number of expansions.

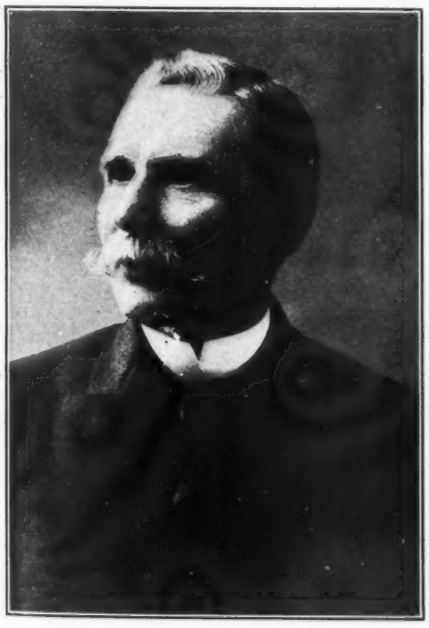
The portion of the stroke accomplished at cutoff is the reciprocal of the number of expansions. If the number of expansions is 4 the point of cutoff will be ¼. For instance, the initial pressure by gage is 93.8 pounds and the terminal pressure is seven pounds; adding 14.7 to each will give 108.5 and 21.7 respectively. Then 21.7 is contained in 108.5 five times and the reciprocal of 5 is ⅕. So with an initial pressure in the cylinder of 93.8 pounds and a terminal pressure of seven pounds, the cutoff, neglecting clearance, would be at one-fifth stroke.

OBITUARY

James H. Blessing

At 3 o'clock on the morning of February 21, James H. Blessing, president of the Albany Steam Trap Company, died at his home in Albany, N. Y. He had been ill with grippe a little over a week and on the Saturday preceding his condition became critical. He sank rapidly from that time until the end came Monday morning. Before the fatal attack of grippe Mr. Blessing had been in his usual health, having been able to attend to his business every day.

Mr. Blessing was born at French's Mills in Albany county in 1837. When he was about five years of age his parents moved to Albany. He attended the public schools until he was 12 years old, when he secured a position as a clerk in a grocery store. In 1853 he was apprenticed to learn the machinist trade with the then well known firm of F. & T. Townsend. His apprenticeship was completed in 1857 and he remained with that firm until 1861. During that time he, with the late Frederick Townsend, invented a breech-loading rifle intended for army use. When the rebellion



JAMES H. BLESSING

broke out, Mr. Blessing entered the United States navy as an acting assistant engineer. He participated at both battles at Fort Fisher.

After the war and until 1866 he was an engineer in charge of the steam machinery of the Brooklyn City Railroad Company. He returned to Albany in 1866 to act as superintendent for Townsend & Jackson's foundry and machine works, successors to the firm with which he served his apprenticeship.

In the year 1870 Mr. Blessing invented the Albany steam trap, and leaving the employ of Townsend & Jackson in 1872, he and Gen. Frederick Townsend engaged in the business of manufacturing and selling steam traps under the firm name of Townsend & Blessing. This business proved successful and in 1875 the Albany Steam Trap Company was formed with three stockholders, the late Gen. Frederick Townsend, the late Henry H. Martin and Mr. Blessing.

In 1899 Mr. Blessing was elected mayor of Albany and during the years of 1900 and 1901 was instrumental in instituting many projects for improving the administration of city affairs. He entered with vigor upon the discharge of every duty which confronted him and labored unceasingly and unselfishly to accomplish what he believed to be for the best interests of his fellow citizens. He was a member of the American Society of Mechanical Engineers and also of the Albany Institute.

Thomas F. Ryan, secretary and treasurer of the company, and also part owner, was associated with Mr. Blessing for 26 years, serving in the capacity of machinist, engineer, foreman, superintendent and finally secretary and treasurer of the company. He is thoroughly familiar and conversant with all phases of the business and it will be continued under his management.

Charles F. Aaron

Charles F. Aaron, general manager of the New York Leather Belting Company, died at his home in Plainfield, N. J., on March 4, following an operation for hernia. Mr. Aaron was one of the best known belting manufacturers in the United States.

He has for years been closely identified with the largest machinery and supply manufacturing interests of the United States. He was, from its organization, prominently identified with the American Supply and Machinery Manufacturers' Association, whose membership represents more than half a billion dollars worth of American factories. He was president of this association from May, 1908, to May, 1909, and prior to that time had for several years been the vice-president and chairman of its executive committee.

Mr. Aaron is best known for his work in this association and outside of it in connection with his efforts for higher standards of production among American manufacturers.

It was largely his inspiration and suggestion that prompted the American Supply and Machinery Manufacturers' Association, in convention at Pittsburg last May, to adopt what was known as its Declaration of Principles. This document, which was unanimously adopted, put all members of that association on record as pledging themselves and their factories to higher qualities in the goods they produced and it condemned the practice of substituting inferior goods as first qualities. The document referred to caused much discussion and favorable comment in the daily and trade press of this country as well as abroad, as being an advance step among American manufacturers for higher qualities and a fit-

CHARLES F. AARON

ting condemnation of the manufacturer of low-grade American products.

Mr. Aaron is perhaps even better known in connection with a campaign he was making up to the time of his death for raising to a higher plane the standards of manufacture of leather belting. He was promoting a plan for general adoption by belting manufacturers of standardizing the specifications upon which all leather belting of first quality should be made. His plan entailed the national adoption by all manufacturers, dealers and consumers of rigid belting specifications, a national stamp or trade mark which should go upon all such goods by whomever manufactured, and a severe penalty to the manufacturer who put out supposedly first-quality goods bearing this stamp which did not fulfil specifications.

Several of the Supply Dealers' Associations now have his plan under advisement of committees, who will report upon it in connection with like reforms in other lines at conventions to be held this spring.

Mr. Aaron is author of the first book ever published in this country describing the whole system of manufacturing leather belting from the time the hide is taken from the steer until it is ready for installation on pulleys.

Mr. Aaron was prominently connected with the Masonic Order, he was a Knight Templar and a Shriner, belonging to Kismet Temple A. A. O. N. M. S. He was also a member of the Elks, of the Machinery Club, and the Crescent Atheltic Club of Brooklyn. He was 43 years old at the time of his death, and leaves a wife and three children.

Joint Meeting of Mechanical Engineers

In response to the invitation of the Institution of Mechanical Engineers to the joint meeting of the Institution of Mechanical Engineers and the American Society of Mechanical Engineers to be held in Birmingham and London in July, 117 members and ladies have already engaged passage on the official steamship "Celtic," while 205 members, with 155 ladies, have signified their intention of going. The following tentative program has been outlined by a committee of the council of the Institution of Mechanical Engineers:

Tuesday, July 26, 1910. *Birmingham.*
Morning, 10 a.m. Reception in Birmingham. Professional session.
Afternoon. Visits to works, and to Stratford, etc.
Evening. Garden fête.

Wednesday, July 27, 1910. *Birmingham.*
Morning. Professional session.
Afternoon. Visits to works, etc.
Evening. Reception in Council House, by invitation of the Right Hon. the Lord Mayor of Birmingham.

Thursday, July 28, 1910.
Whole-day excusions; arriving in London in time to reach hotels and attend late conversazione at the institution.

Friday, July 29, 1910. *London.*
Morning. Professional session at the Institution of Civil Engineers.
Afternoon. Visits and social functions.
Evening. The institution dinner. Including ladies.

Saturday, July 30, 1910. *London.*
Whole-day excursions, Windsor and Henley (by invitation).
Evening. Reception at the Japanese-British exhibition. By invitation.

PERSONAL

W. G. Lighty, for several years engineer of the Schiller building, has just been appointed chief engineer of the Farnham-Willoughby interests with headquarters at 72 Madison street, and will have entire charge of the operation of all the plants in the loop district of Chicago operated by this company. The change took place March 1.

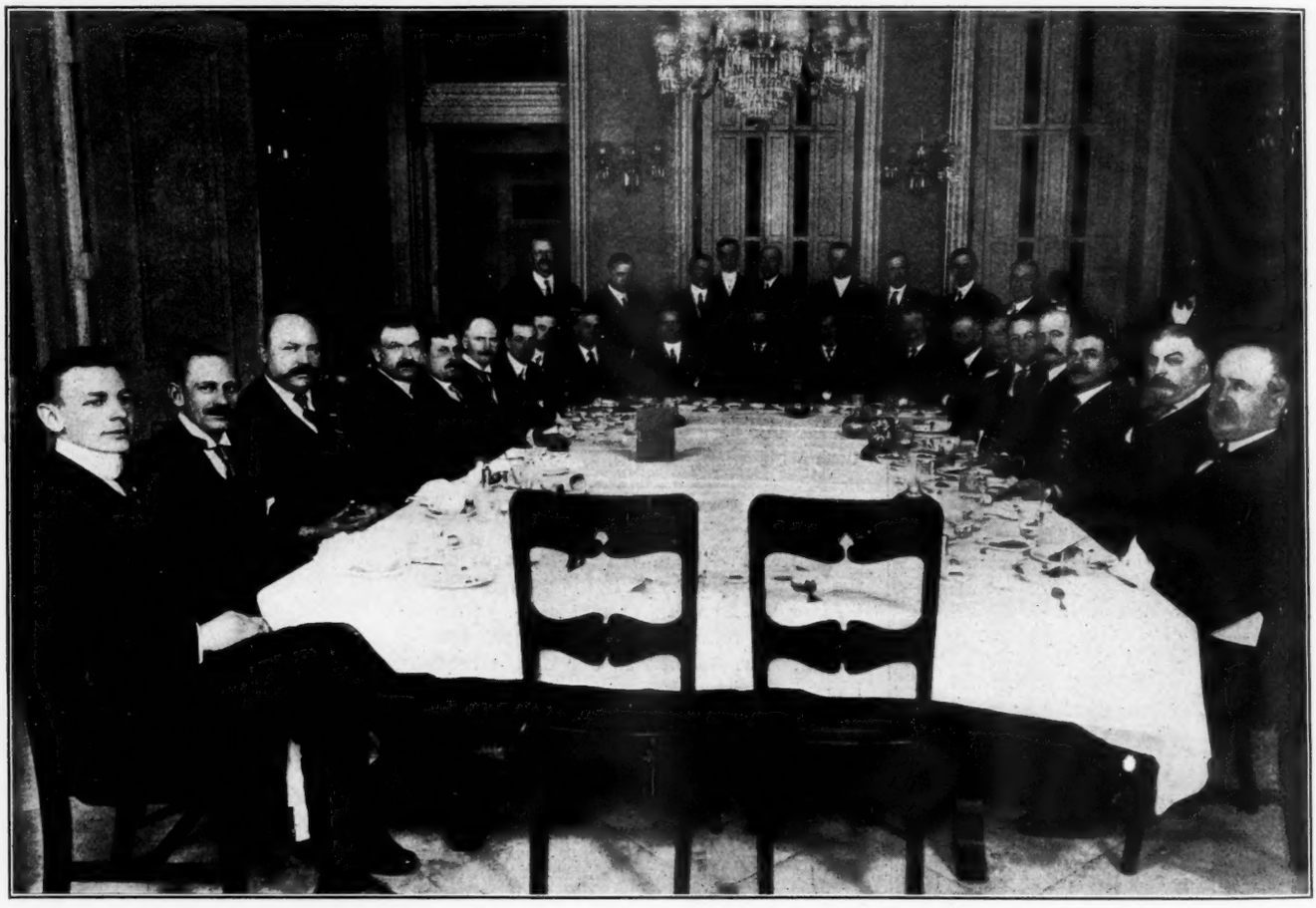
B. S. Hughes, formerly connected with the Champion Coated Paper Company, of Hamilton, O., and the Champion Fiber Company, of Canton, N. C., as consulting engineer in charge of all engineering work of construction and operation, has opened a consulting office in the Commercial Tribune building, Cincinnati.

SOCIETY NOTES

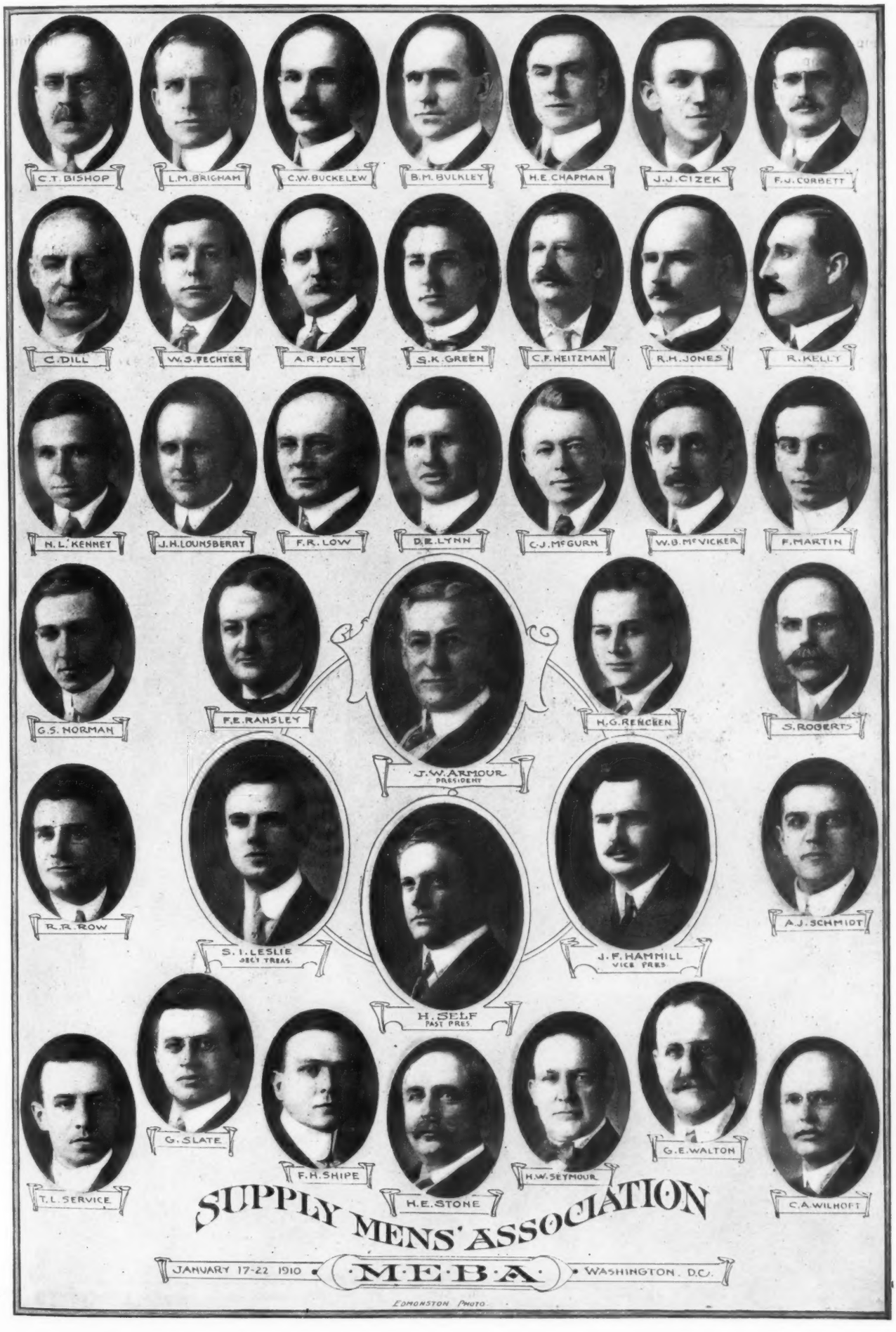
On the evening of Saturday, February 19, David Townsend, mechanical engineer, of Philadelphia, Penn., delivered a lecture on "Economy of Combustion and Smoke Prevention" before the Stevenson Association No. 44 of the N. A. S. E.

The topic, which is of timely importance and interest, was treated in a thorough and masterly way. Mr. Townsend's long experience with this special phase of engineering qualifies him to speak with authority upon the subject.

At a recent meeting of the council of the American Society of Mechanical Engineers the election of Rear Admiral George W. Melville to honorary membership by a unanimous ballot was announced, and the degree will be formally conferred at the spring meeting at Atlantic City on Wednesday evening, June 1.



NEW YORK MARINE ENGINEERS' TABLE AT THE EBBITT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B.M. BULKLEY
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NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

PRIME MOVERS

APPARATUS FOR UTILIZING THE MOVEMENT OF THE SEA WAVES. Agostino Ravelli, Capriata d'orba, near Alessandria, Italy. 947,846.

MACHINERY FOR PRODUCING MOTIVE POWER. Charles Tellier, Paris, France. 947,867.

STEAM TURBINE. Wellington Kilmer, Hyde Park, Mass. 948,176.

ROTARY ENGINE. William G. Sheppard, Indianola, Neb. 948,256.

INTERNAL COMBUSTION ENGINE. Edward C. Bennett, Wormleysburg, Penn. 948,103.

SUBMERGED WATER WHEEL. William B. Campbell, Toppenish, Wash. 948,105.

AIR AND GAS ENGINE. Baxter M. Aslakson, Salem, Ohio. 949,139.

OSCILLATING MOTOR. George Heger, Milwaukee, Wis., assignor of one-half to William F. Barenz, Milwaukee, Wis. 949,372.

ROTARY ENGINE. Karl J. Hokanson, Minneapolis, Minn. 949,431.

ROTARY ENGINE. Franklin Tompkins, New Dorp, N. Y. 949,510.

ENGINE DRIVEN BY INNER COMBUSTION MOTOR. Adolph Klose, Halensee, near Berlin, Germany. 949,580.

ROTARY MOTOR. William Taylor, Minot, N. D. 949,605.

ROTARY AIR COMPRESSOR. Frank Peck, Rochester, N. Y., assignor to the Peck Air Compressor Company, Rochester, N. Y., a Corporation of New York. 949,714.

WATER MOTOR. Henry C. Phillippi, Reading, Penn. 949,715.

CURRENT MOTOR. James W. Myers, Robinson, Ill., assignor to Myers Motor Co., a Corporation of Illinois. 949,747.

BOILERS, FURNACES AND GAS PRODUCERS

FURNACE FIRE DOOR. George H. Gregory, Mount Carmel, Ill. 948,218.

GAS PRODUCER. Josef Reuleaux, Wilkinsburg, Penn., assignor to Alexander Laughlin, Sewickely, Penn. 948,249.

BOILER. Godfrey Engel, Pittsburg, Penn. 948,271.

BOILER FURNACE. Charles H. Wilson, Paducah, Ky. 949,048.

GRATE. John W. Fowler, Scranton, Penn. 949,065.

OIL BURNER. Jonas H. Herriff, Erie, Kan. 949,073.

RENEWABLE GRATE BAR LEAF. Thos. S. Johnson, Scranton, Penn., assignor to Scranton Steam Pump Co., Scranton, Penn. 949,079.

CRUDE-OIL BURNER. Frederick D. Stalford, Frederick, Okla. 949,133.

STEAM BOILER SUPERHEATER. Francis J. Cole and Henry B. Oatley, Schenectady, N. Y. 949,147.

HYDROCARBON BURNER. Daniel W. Young, Jr., Sycamore, Ill. 949,167.

FURNACE CONSTRUCTION. Stephen D. Oliphant, Beaver, Penn. 949,402.

APPARATUS FOR REGULATING COMBUSTION. George W. Parker, New York, N. Y., assignor to the Parker-Russell Mining and Manufacturing Co., St. Louis, Mo., a Corporation of Missouri. 949,596.

FLUE POINT AND ITS ATTACHMENT TO FLUE SHEETS. Charles S. Coleman, Spokane, Wash., assignor to Railway Improvement Co., Spokane, Wash., a Corporation. 949,621.

BOILER TUBE AND FLUE CLEANER. Harry S. Stormer, Johnstown, Penn. 949,637.

FURNACE GRATE BAR. Edward L. Thomas, Valdosta, Ga. 949,639.

OIL BURNER. McClure W. Cowan and David Felten, Parsons, Kan. 949,648.

MEANS FOR CONTROLLING DRAFT AIR TO BOILER FURNACES. Lucas Duffner, St. Louis, Mo. 947,804.

OIL BURNING SYSTEM. Holmes Duke, Beaumont, Tex. 947,890.

FURNACE DOOR OPERATING DEVICE. Oliver M. Gossett, Seymour, Ind. 947,903.

BOILER-CLEANSING APPARATUS. John Zetka, Newark, N. J. 947,955.

ELECTRICAL APPLIANCES

APPARATUS FOR ALTERNATING THE POLARITY OF CURRENT IN ELECTRIC CIRCUITS. Garrison Babcock, Rochester, N. Y., assignor to Telechronometer Company, Rochester, N. Y., a Corporation of New York. 947,781.

CONTACT DEVICE FOR ELECTRICALLY WOUND MECHANISM. Benjamin F. Kessler, Mount Carmel, Penn. 947,821.

ELECTRIC FURNACE. James H. Reid, Newark, N. J. 947,849.

ROTARY CURRENT BREAKER. Hermann Ruthardt, Stuttgart, Germany. 947,853.

FUSELESS ROSETTE. Herbert C. Wirt, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 947,878.

SNAP SWITCH. Henry P. Ball, New York, N. Y., assignor to General Electric Company, a Corporation of New York. 947,881.

ELECTRIC AIR COMPRESSOR. Asa F. Batchelder, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. 947,882.

ELECTRIC ARC LAMP. Theodor J. Rensing, Leipzig, Germany, assignor to Korting & Mathiesen Aktiengesellschaft, Leutzsch, near Leipzig, Germany. 947,979.

COMBINED ELECTRIC CONNECTING PLUG, SOCKET AND SWITCH. William W. Buckton, Westminster, London, England. 948,041.

ELECTROPLATING APPARATUS. Willis R. King, Newark, N. J., assignor to Hanson and Van Winkle, a Corporation of New Jersey. 948,056.

ELECTRIC-LIGHT FIXTURE. William A. Hutton, Scranton, Penn. 948,095.

BATTERY BOX. Russell W. Magna, Holyoke, Mass. 948,111.

ELECTRORHEOSTAT REGULATOR. Hugo Gernsback, New York, N. Y. 948,275.

ELECTRIC FUSIBLE CUT OUT. Ernest Schattner, Ealing, England. 948,296.

PROCESS OF PRODUCING ELECTROLYTIC COPPER. Alexander S. Ramage, Newark, N. J., assignor to Chemical Development Co., Buffalo, N. Y., a Corporation of Colorado. 949,003.

ELECTROLYTIC APPARATUS FOR RECOVERING METALS FROM SOLUTIONS. Wilbur A. Hendryx, Denver, Colo. 949,016.

ELECTRIC ARC LAMP. John C. Lincoln, Cleveland, Ohio, assignor to the Lincoln Company, Cleveland, Ohio, a Corporation of Ohio. 949,081.

TRANSFORMER CASE CONSTRUCTION. Louis C. Nichols, Norwood, Ohio, assignor to the Bullock Electric Mfg. Co., a Corporation of Ohio. 949,086.

MOTOR-CONTROL SYSTEM. Emmett W. Stull, Norwood, Ohio, assignor to Allis-Chalmers Company, a Corporation of New Jersey. 949,097.

COMMUTATOR FOR DYNAMO-ELECTRIC MACHINES. Miles Walker, Manchester, England, assignor to Westinghouse Elec. & Mfg. Co., a Corporation of Pennsylvania. 949,103.

SYSTEM OF ELECTRIC-MOTOR CONTROL. William Cooper, Pittsburg, Penn., assignor, by mesne assignments, to Westinghouse Electric & Mfg. Co., East Pittsburg, Penn., a Corporation of Pennsylvania. 949,114.

ELECTRIC CLOCK SYNCHRONIZING APPARATUS. Ernest A. Hummel, St. Paul, Minn., assignor to Albert L. Haman, St. Paul, Minn. 949,122.

ELECTRIC SWITCH. Chas. J. Klein, New York, N. Y., assignor, by mesne assignments, to Ida S. Rosenheim, New York, N. Y. 949,123.

POLE-LINE LIGHTNING ARRESTER. Alfonso R. Rheinberger, St. Paul, Minn. 949,130.

SECONDARY OR STORAGE BATTERY. Charles H. Clare, Stratham, N. H. 949,146.

ELECTRIC ARC LAMP. John C. Lincoln, Cleveland, Ohio, assignor to the Lincoln Company, Cleveland, Ohio, a Corporation of Ohio. 949,151.

METALLIC-FILAMENT INCANDESCENT LAMP. Wilhelm Majert, Berlin, Germany 949,153.

HIGH-POTENTIAL SWITCH. Frank O. Hartman, Mansfield, Ohio. 949,182.

INSULATOR FOR HIGH-POTENTIAL CIRCUITS. Joseph N. Kelman, Los Angeles, Cal. 949,189.

SECONDARY OR STORAGE BATTERY. Bruce Ford, Philadelphia, Penn. 949,225.

ELECTRIC LAMP SOCKET. Reuben B. Benjamin, Chicago, Ill., assignor to Benjamin Electric Mfg. Co., Chicago, Ill., a Corporation of Illinois. 949,209.

CONNECTING DEVICE FOR CIRCUIT WIRE COVERING PIPES. Thomas E. Murray, New York, N. Y. 949,243.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., George Westinghouse; sec., Calvin W. Rice, Engineering building, 29 West 39th St., New York. Monthly meetings in New York City. Spring meeting at Atlantic City, May 31 to June 6.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff, Denver, Colo.; sec. and treas., Frank M. Tait. Association York. Next annual convention, St. Louis, Mo., May 23-28.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

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AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., L. B. Stillwell; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly, excepting July and August.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., William G. Snow; sec., William M. Mackay, P. O. Box 1818, New York City.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., William J. Reynolds, Hoboken, N. J.; sec., F. W. Raven, 325 Dearborn street, Chicago, Ill. Next convention, Rochester, N. Y., September, 1910.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, W. S. Cadwell, Chicago, Ill.; sec., Thomas H. Jones, 244 Eighth street, N. E., Washington, D. C. Next convention, Buffalo, N. Y., August 2-5, 1910.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next convention, Philadelphia, Pa., June, 1910.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS.

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting, St. Louis, Mo., January 16-21, 1911.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; sec. and treas., Prof. F. E. Sanborn, Ohio State University, Columbus, Ohio.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. E. Brown; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Niagara Falls, Canada, May 24-27, 1910.

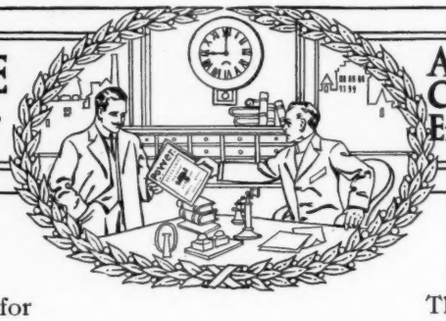
INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., Robert A. McKee, Peoria, Ill. Next convention, Denver, Colo. September, 1910.

NATIONAL DISTRICT HEATING ASSOCIATION.

Pres., A. C. Rogers, Toledo, O.; sec. and treas., D. L. Gaskill, Greenville, O. Next annual meeting at Toledo, O., May, 1910.

MOMENTS WITH THE Advertising Editor



A Department for Subscribers Conducted by the Business End of Power and the Engineer

Here is the other side of the story—and it's *true*.

It makes good reading for both man and boss.

These little advertising anecdotes have served to show that it pays to read advertisements and buy advertised goods.

And they have aimed to prove that it pays to put things up to the Old Man when the thing put up will promote efficiency or produce economy.

Awhile ago a Master Mechanic in a well-known plant suggested to "Headquarters" that they install a feed water heater, feed water regulators and pump governors.

None of these things had been used by the firm and the M. M. saw the possibilities of saving money with them.

"Pish, tush, punk" was what the Old Man's reply to the M. M.'s plea sounded like. "For umpsteen years have we run our plant without these Trifles—far be it from us to put them in now."

But the Master Mechanic, possessed of a fair share of determination, persisted in his attempt to get things right and finally induced the Old Man to secure prices on the equipment.

The lowest bidder came in with a $2000 bid for the job—and the Old Man's heels hit the ceiling.

"Never-r-r!" was his emphatic answer. "All that real money for a luxury? Never-r-r!"

Now, the Lowest Bidder was used to this sort of thing, so he quietly made an investigation and came back with an offer to put in the apparatus and take as payment *part* of the money it *saved* for a period of 20 months!

This looked so easy to the Old Man that he promptly sewed up the Lowest Bidder in a contract that he couldn't squirm out of without losing a leg.

The apparatus was put in on the first of last September, and from the start the saving in *coal alone* has amounted to from $12.00 to $18.00 per day!

At the end of the contract the Old Man will have paid something like $8,000 or $10,000 for the $2,000 worth of equipment.

And all of this out of *savings* it has made.

He is willing to settle now for $3,500.

And we don't blame him.

* * * *

There are several morals to that story:

The Master Mechanic knew his business and proved it by planning the installation of money-saving equipment.

The Boss paid the Man a salary for what the Man knew—and disregarded his advice.

The installation of modern machinery works wonders in plants that today are costing more to operate than is necessary, and that are not developing complete efficiency at any price.

* * * *

Fortunately, the percentage of concerns that will not listen to the advice of their engineer or master mechanic is growing beautifully less.

The percentage of power plant men who read the advertisements in this paper and buy therefrom, or who recommend buying advertised goods, is growing larger.

And that is as it should be—not because we say so or hope so or think so, but because advertised goods are *reliable* and advertisements *truthful*.

They *have* to be. Every statement in an advertisement has to pass you practical men whose knowledge of facts will smash the lie to smithereens.

Every machine must live up to claims or your universal disapprobation will put it out of business.

The medicine man can hand out a fancy line of talk that lures the tinkling dollar from the cracked teapot or the crisp bill from the Stocking Bank *only because he leaves town the same night.*

Advertisers of power plant equipment are in business to stay.

When a manufacturer says that his article is "best" and the other fellows tell you that theirs are "best," all of them believe what they say.

Each has certain features in his machine which he believes makes it the "best" machine of its kind, or the best for certain purposes and certain conditions.

Then it focuses down to a matter of *opinion* or choice—and *yours* is the opinion or choice that decides.

Advertising and dynamite are both useful, but the results from both depend upon how they are handled.

Get a "Gates Ajar" ready for the man who mishandles his advertising "copy."

For, verily, he is already buried.